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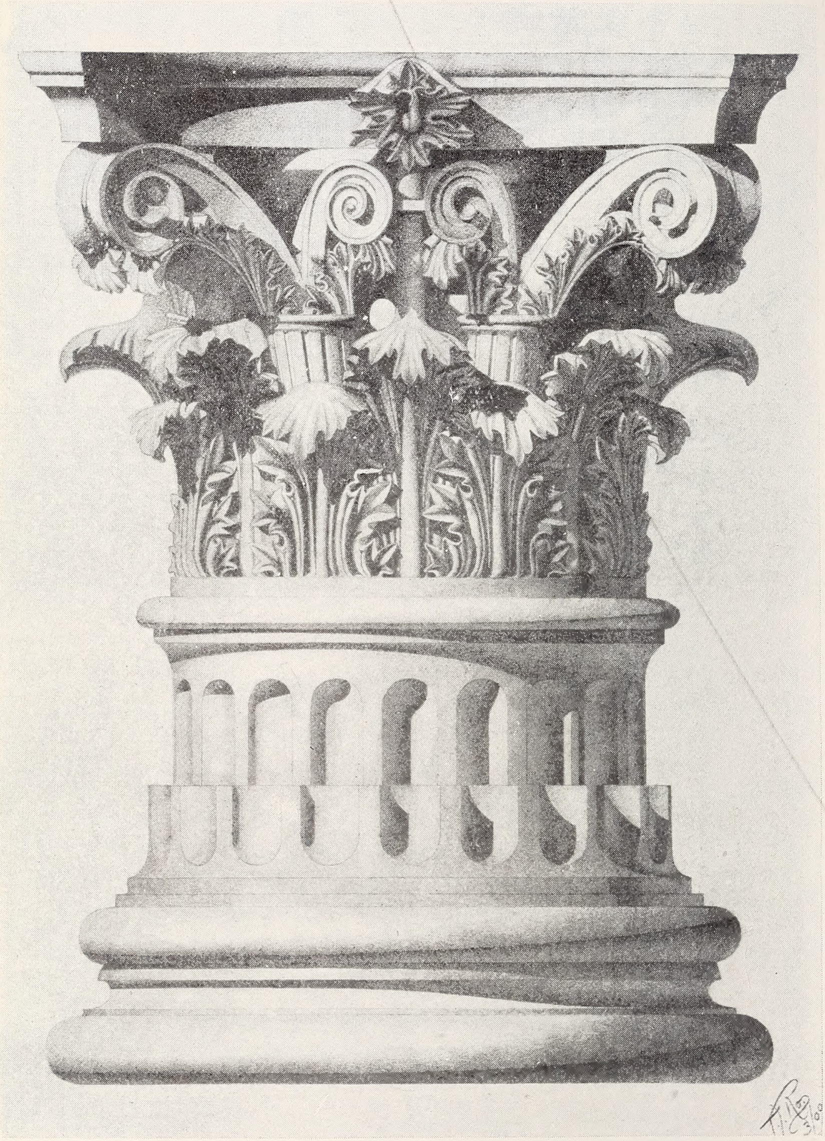

Drawn by T. L. F. Rowe when a First Year Student in the Department of Architecture.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF
TORONTO ENGINEERING SOCIETY

Old Series Vol. 23 FEBRUARY, 1911 New Series Vol. IV. No. 4

INCANDESCENT LAMPS.*

M. B. HASTINGS. '11.

Illuminating engineering is simply the engineering method applied to the production, the sale and the use of light. Now, as this paper must be short I have decided to confine my few remarks to the manufacturing and testing of lamps. Hence the title "Incandescent Lamps."

Incandescent lamps, as we are all aware, are divided into four separate and distinct classes, namely, Carbon, with an efficiency of 3.1 w.p.c.; Gem, which is an improved carbon with an efficiency of 2.5 w.p.c.; Tantalum with an efficiency of 2 w.p.c.; and Tungsten with an efficiency of 1.25 w.p.c.

As the Carbon lamp is the first to come into prominence it might be proper to mention a few words with regard to its manufacture. The filaments of the first carbon lamps consisted of strips of woody plants such as bamboo, and vegetable fibres, such as cotton threads, and strips of paper and animal fibres, such as silk, but none of these materials mentioned were found sufficiently uniform in structure, density, electrical resistance and character of surface. The first promising effort to gain uniformity was the effort to parchmentize the outer portion of the cotton threads usually by soaking a limited time in sulphuric acid, but this resulted in a fibre covered with lumps and irregular in section. This objection was overcome by drawing the filament through a series of dies. This process pointed the way to the evidently logical procedure of breaking up the cellular structure entirely, converting it into a viscous compound which could be pressed through an orifice into a coagulent, thus forming a thread of cellulous without structure. Any chemical capable of dissolving cotton may be used, a strong hot solution of zinc chloride being the most common. A solution of gun cotton on acetic acid is used, to some extent, principally in European factories.

The process of dissolving the cotton for carbon filaments in a zinc chloride solution takes the form of a heavy syrup. It is then evacuated at a temperature below the boiling point of water until occluded air and gas are removed. All conditions must be uniformly maintained. After cooling the mass is forced through platinum dies by air pressure, the end of the dies extending about ½ in. into a jar of alcohol, which coagulates the jet of solutions as it emerges from the die. The glass jar containing the alcohol revolves about one revolution in 3 min. which keeps the fibre from tangling as it lays itself down in coils. Inside the glass jar is a hard rubber basket into which the fibre is coiled. One of these baskets will hold enough fibre for 1800 — 2 c.p. 110 volt lamps while it will only hold enough for about 300 — 50 c.p. 50 volt lamps. After standing in alcohol for about 12 hours these fibres are washed, first in a solution of hydrochloric acid water for about 3 hours, then in distilled water for about 2 hours. The idea is to dissolve out all soluble salts from the fibre, leaving only pure carbon with traces of insoluble salts. The latter are afterwards evaporated by the heat of carbonization. If the salts were not almost wholly removed from the fibre the carbon would be porous and brittle. After washing the fibre is wound upon drums about 4 ft. in diameter where it dries. After the fibre is taken from the drum it is wrapped either upon carbon blocks or forms to give the desired shape, and carbonized at a temperature of about 3000 degrees Centigrade. After carbonization the filaments are assorted, cut for length and electrically heated in the presence of paraffine hydro carbon gas. The carbon deposited upon the filament from this gives it a better light radiating surface, also the deposit causes the resistance of the individual carbons to be brought closer together. The amount of deposits is governed exactly by automatic devices. After the carbons have received this coating they are put in stock for factory use. The glass tubing from which the stems containing the platinum leading in wires are made is bought from the glass factory in 3 or 4 foot lengths. This tubing is cut into lengths varying from 1 to 2 in. on a carborundum wheel. These pieces are then placed in an automatic flange rolling machine. From these machines the flanges are taken, assorted and inspected. They are then taken by the stem machine operators, and with the platinum and copper leading in wires together with the anchor wire they are made into stems which after inspection are ready for the clamping department. In this department the stem and filament meet. The operators cement the carbon to the platinum wires by a graphite cement, after which they are baked until the joint will stand soaking in water for 4 or 5 hours without coming loose. We now have the carbon cemented to the platinum leading in wires, ready to be sealed into the bulb. They are then sealed into the bulb and the vacuum is obtained, similar to the process which will be described later in the discussion of the Tungsten lamp.

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*Read before the Engineeriug Society, January 25th, 1911.

Tungsten Lamps.

Within the last few years wires of rare metals have been substituted for the older carbon wires or filaments. Tantalum and Tungsten metals have proven best adaptable for this purpose, and it is the Tungsten lamp especially that this paper is designed to discuss.

Tungsten lamps are manufactured from the ore known as Wolframite, an oxide of manganese, iron and Tungsten (wolfram). Tungsten oxide is now chemically obtained from the crushed ore. Metallic Tungsten, as a powder, is now reduced from the yellow oxide. The paste process by which a large majority of Tungsten lamps is made is as follows: Tungstic acid, as received by the lamp manufacturer, is in the form of a heavy yellow colored powder, and notwithstanding its purity has to undergo a most thorough purification ,and special treatment in order to reduce it to a fine yellowish powder which possesses a slight porosity. This peculiar physical condition is necessary for the successful reduction of the oxide which can be accomplished in several different ways, perhaps most easily by heating to redness in a current of hydrogen. After obtaining this very pure metallic Tungsten the next operation is to mix it with combining material in order to form a plastic mass that may be squirted into the fine threadlike filaments. Some substances can be used for this purpose, but some compound of carbon, oxygen and hydrogen, such as starch, sugar, camphor, etc., is usually employed. The metallic powder when mixed with such combining material has the same consistency and appearance as black putty. It is absolutely smooth and uniform and it is impossible to detect the slightest grain. This paste, as it is called, is placed in a small steel cylinder and forced by a pressure of about 32,000 lbs. per sq. in. through a small diamond die.

The die used in squirting Tungsten filament consists of a suitably mounted diamond of from one-half to one carat in weight, through which a very minute hole has been drilled. In the smaller dies used to-day this hole is only about 0.0014 in. in diameter, which is smaller than an ordinary hair. The hole is drilled in the diamond with a steel needle, ground down so fine that it is as flexible as a hair, and, as can be imagined, the drilling requires considerable time and patience. The stone when drilled is mounted in a steel casting in order to hold it against the enormous pressure used in squirting the filament.

Under such pressure the wearing of the die even by smooth tungsten paste is very rapid. This wearing is a serious matter, as the diameter of the hole, and consequently that of the filament squirted, constantly increases. Moreover, the wearing is not uniform, so that the hole enlarges more rapidly in the direction of one diameter than the other, assuming when worn an elliptical shape. After enough filament for about 1,500 lamps has been squirted it is necessary to have the die rebored, an operation which costs almost as much as the original die. A die cannot be rebored more than twice before it develops cracks or fissures which cause it to break. The next hardest material, sapphire, has been experimented with as a material for these dies, but it is found that such a die is very liable to split, and that it will hardly make 100 lamps before it needs re-drilling.

The filament, after squirting has been likened in character to a filament of putty, that is, while holding its form well and being flexible to some extent, it is liable to break if bent sharply. The filament as squirted is looped back and forth on cards, and after being allowed to dry is cut to form a number of single loops, much as they are seen in the finished lamp.

The next operation is to beat the filaments in an inert gas, or in one chosen to act upon the particular binding material employed, until they reach a red heat which removes any moisture and lighter hydrocarbons that may be present. Each filament is then mounted in a current conducting clips, so that it may be heated by passing an electric current through it. During this final heating or forming, as it is termed, the filament is supported vertically with the loop downward. A very small weight (a few milligrams) is hung in the loop to prevent the filament from being distorted in shape during the heating, which is usually performed in either inert gas or in a very good vacuum, the gas, if used, being again dependent to some extent on the binding material employed. The temperature of the filament is raised gradually, allowing time for the proper reactions and physical changes to take place. During the heating the energy put into the filament rises to about fifteen times that finally required in the lamp, and while some heat is carried away by the forming gas the temperature is undoubtedly much higher than that reached in subsequent operation.

Every trace of binding material is driven out, and the filament when finally brought to a sufficiently high temperature undergoes a sudden and marked contraction in diameter and length as the small semi-molten particles become soft enough to merge into one perfectly homogeneous mass. A piece of such filament under a microscope resembles a drawn wire, and while the surface is not perfectly smooth there is no indication of a granular structure.

At a dull red heat any good tungsten filament is flexible enough to be bent as desired, but when cold is somewhat fragile. For this reason it is a good thing, if possible, to light tungsten lamps while cleaning them, the chance of mechanical breakages being then minimized.

In order to secure a uniform quality of filament, which is absolutely necessary for good lamp making, every step of the entire process of production, even to the smallest detail, must be carried through with exactness. For example, the rate at which the temperature of the filament is raised during the forming process has a most important effect on the final filament structure, and must be carried out with extreme care in order to assure a perfectly uniform run of filament.

After forming the filaments are mounted upon the familiar glass supporting rod as seen in the finished lamp, and the joint between each leg and the supporting and conducting terminal made by electrically welding the filament to the support. This makes a very perfect joint, both electrically and mechanically.

The material used for the hooks and supporting wires affects the performance of the lamp to a considerable extent. Soft copper is used extensively for such supports, also to a somewhat lesser extent, molybdenum, tungsten, tantalum, carbon, platinum or other refractory materials. Soft copper does not alloy with pure tungsten, and moreover occludes but very little gas, so that it makes a very satisfactory form of supporting hook.

The process of producing a high vacuum within the bulb of a tungsten lamp is a great deal more laborious than in the case of the carbon lamp. It is necessary in order to produce a good lamp, and this applies to carbon and other types as well, to remove every trace of gas, not only that actually free at the time of pumping, but that which may later be liberated from anything within the finished bulb. A good lamp vacuum is only possible through the use of very perfect exhausting machinery and through subjecting the entire lamp, filament, glass, and other parts to a proper heat treatment, during the pumping process. The heat treatment tends to drive from the glass walls and other surfaces exposed within the bulb the particles of air which cling to them in a thin film with surprising persistence. A glass bulb pumped while cold will apparently reach a high degree of exhaustion at the end of the pumping process but, if left standing for some time, will be found to possess a very poor vacuum as judged from that required to insure a good lamp performance. This is due to the gradual liberation of particles of air which, during the pumping, cling to the interior surfaces. The filament is heated intensely by passing an electric current through it while on the pump in order to drive from it and from the supporting wires, which are heated by the incandescences of the filament, any occluded gas which may later be freed from these parts and thus spoil to a certain extent the perfect vacuum required for successful operation. During the pumping process the filament temperature must be regulated with great care, the temperature being raised gradually as the bulb becomes evacuated. If, for example, the temperature should be raised too quickly, a thin film of oxide will form on the surface of the filament, which although entirely removed by a further rise in temperature and higher degree of exhaustion, will have been found to have caused a slight change in the character of the surface of the filament, altering thereby its emissivity and radiating properties and injuring its subsequent life performance.

After pumping, the lamps are given an exhaust inspection and aging by burning at a certain percentage over voltage. If, during this inspection, any lamp develops or shows a bluish color or haziness within the bulb it is an indication of imperfect vacuum and the lamp is rejected. The period of burning and per cent. over voltage depends somewhat on the size of the lamp, but in every case has been chosen so that if a lamp is at all likely to develop a poor vacuum it will be disclosed on this inspection.

The glass work required in making the tungsten lamps, is, with the exception of the centre glass stem, practically the same as in the other types of incandescent lamps.

I have now covered in a general way the process of producing the tungsten lamps, and have, I hope, given some slight idea as to the care required in such production. In order to show the performance of the lamps in subsequent service I have at my disposal, loaned by the N. E. L. A., the averaged candle power life curves of 50-40 watt tungsten lamps which were burned on life test at constant voltage corresponding to an initial consumption of 1.25 watts per mean horizontal candle power. The curves in Fig. 1 show the change in candle power, current and efficiency during the period of test, which was stopped at about 1,400 hours. In order to show the life performance, a curve is given showing the per cent. of lamps which were burning at

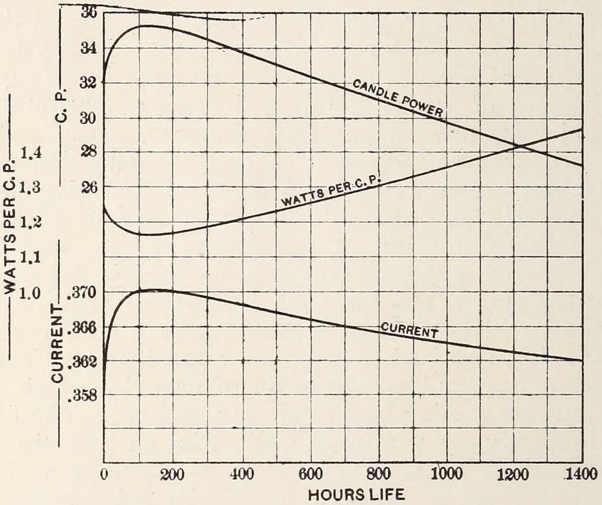


FIG 1 —Characteristic performance of 40-watt tungsten lamps

the end of various periods of time. These curves, Fig. 2, are the average obtained from 80-40 watt tungsten lamps burned under same conditions as the previous test, i.e., at 1.25 w.p.c. About one-half of the lamps were burned in a horizontal position and others in a vertical position, tip downward. These tests were stopped at the end of 2,000 hours.

The change in appearance of the filament during life is rather interesting, and some illustrations showing filaments taken from lamps which had been burned for various lengths of time are shown in Figs. 3 to 23. For comparison, a few tantalum filaments, as well as a few filaments from a gem and from a carbon lamp are shown.

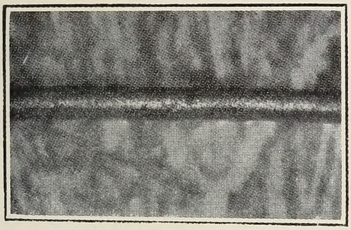


Fig. 3.—Unmounted tungsten filament.

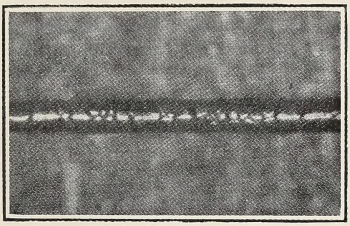


Fig. 4.—25-watt tungsten—400 hr.—alternating current.

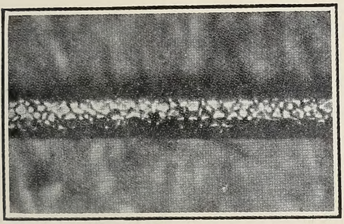


Fig. 5.—40-watt tungsten—180 hr. —alternating current.

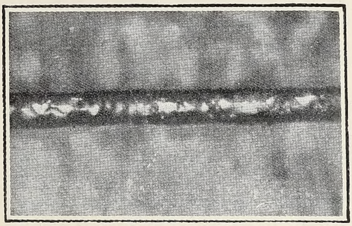


Fig. 6.—25-watt tungsten—1400 hr.—alternating current.

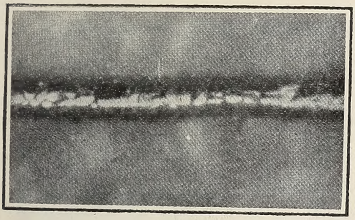


Fig. 7.—40-watt tungsten—898 hr.—alternating current.

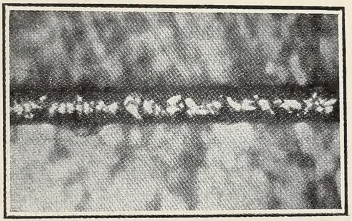


Fig. 8.—40-watt tungsten 2190 hr.—alternating current.

To show the effect of a varying line voltage an increase of 6 per cent. in the voltage of a carbon lamp increases the per cent. candle power as much as an increase of 9 per cent. in voltage of the tungsten lamp. While a tungsten lamp of 10 per cent. under voltage drops in per cent. candle power only as much as a carbon lamp, 7 per cent. below normal. For a circuit where the regulation is poor, the tungsten lamp will be found to give much better satisfaction as far as variation of candle power is concerned than the carbon lamp. The size and filament required in lamps of various candle powers and voltages varies considerably. For 110 volts the size and length varies from a diameter of 0.0013 in. and a total length of 17.4 in. for a 25-watt lamp to a diameter of 0.0060 in., and a total length of 37.56 in. for a 250-watt lamp.

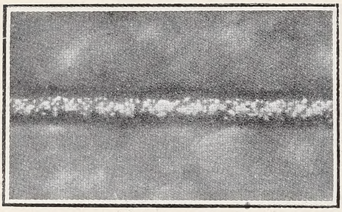


Fig. 9.—40-watt tungsten—300 hr.—direct current.

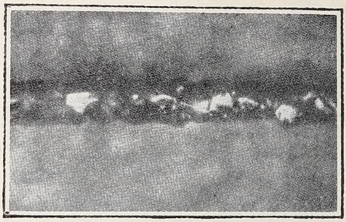


Fig. 10.—40-watt tungsten—3000 hr.—direct current.

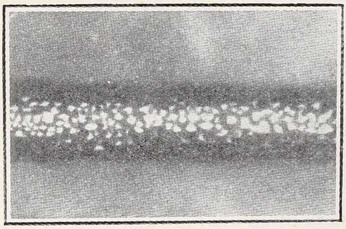


Fig. 11.—100-watt tungsten—1400 hr.—alternating current.

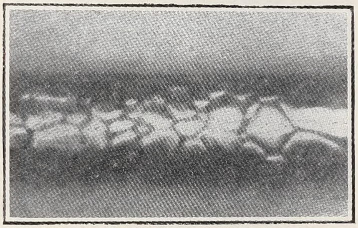


Fig. 12.—250-watt tungsten—200 hr.—alternating current.

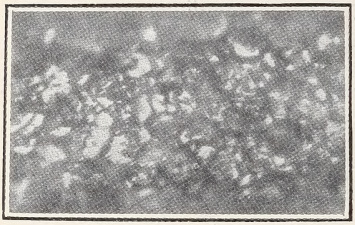


Fig. 13.—Tungsten—street series—2000 hr.

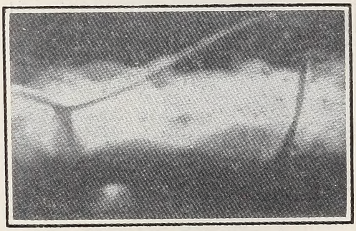


Fig. 14.—Tungsten—street series—2349 hr.

The specific resistance of tungsten is about 46.5 ohms per mil-inch at a temperature corresponding to 1.25 w.p.c., and about 9 per cent. of this figure or 4.19 ohms per mil-inch at ordinary room temperature. This low cold resistance has led to a good deal of discussion as to the value of the starting current obtained upon closing the circuit of a tungsten lamp and its effect upon the filament.

The question is of particular importance when the lamps are turned on and off continuously, as for example, in flashing sign work.

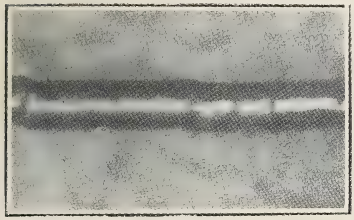


Fig. 15.—80-watt tantalum—800 hr.—alternating current.

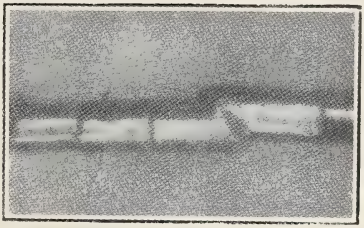


Fig. 16.—80-watt alternating—400 hr.—80-watt alternating current.

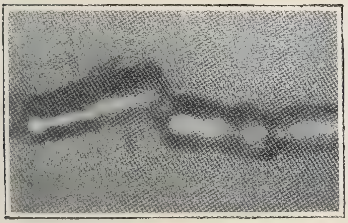


Fig. 17.—40-watt tantalum—800 hr.—alternating current.

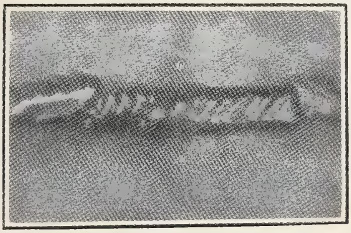


Fig. 18.—80-watt tantalum—948 hr.—alternating current.

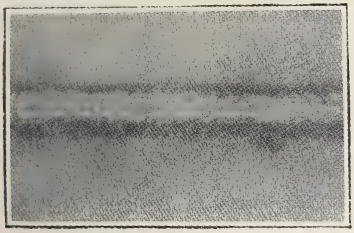


Fig. 19.—80-watt tantalum—60 hr.—direct current.

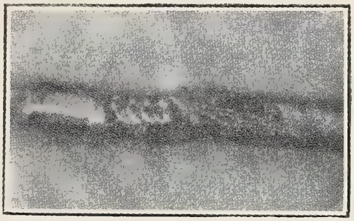


Fig. 20.—80-watt tantalum—455 hr.—direct current.

To most people incandescent lamps are pear-shaped bottles of two or three sizes used for store and residence illumination. As a matter of fact, there are 435 sizes, styles and types of incandescent lamps, and they are used for every conceivable service from street lighting to the illumination of stomach interiors in surgical work. These lamps range from 1-10 to 400 c.p. There are 97 separate sizes and types of bulbs used and 26 sizes and styles of base. There are 22 different types of filaments. If all the different voltages, efficiencies, styles and types are taken into account there are in practice not less than 2,500 distinct lamps.

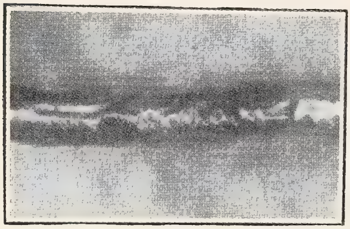


FIG. 21.—80-watt tantalum—1058 hr.—direct current.

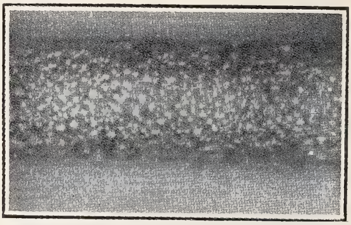


FIG. 22.—Gem—841. hr.

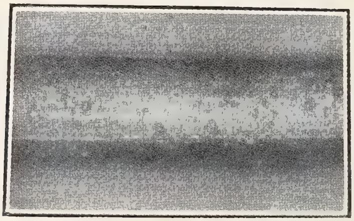


FIG. 23.—Carbon—508 hr.

It may be interesting to explain how characteristics of these lamps are obtained, that is, the data necessary for testing these lamps from a mathematical and scientific standpoint-basis.

The tungsten lamp is measured at a voltage which will make it burn at 1.25 w.p.c., the candle-power, watts, amperes, ohms and volts are plotted and as these readings are from the lamp at its normal condition they are recorded as 100 per cent.

Corresponding readings are taken as the candle-power is lowered to 20 per cent. normal and raised to 150 per cent. of normal. For the normal range of operation these curves can be expressed in the form of parabolic equations, a few of which are given as follows.

Let c = candle-power.
e = efficiency in watts per candle.

V = voltage.
W = watts.

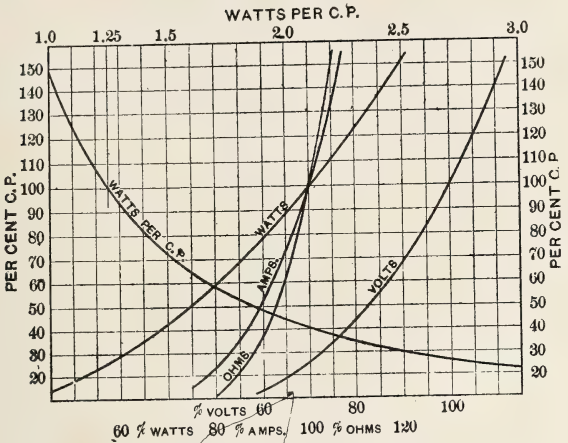


FIG. 24 —Performance of tungsten filament lamp

$$\frac{c_1}{c_2} = \left(\frac{e_2}{e_1}\right)^a = \left(\frac{V_1}{V_2}\right)^b$$

$$\frac{W_1}{W_2} = \left(\frac{V_1}{V_2}\right)^d$$

Values of exponents "a," "b," and "d" are obtained by plotting the corresponding curve on log section paper and measuring the tangent of the angle, which is the value of the exponent required.

These performance curves are of indispensable value in the engineering department in connection with life testing of the lamps sent in by the different factories.

Within the last year the basis of candle-power has changed from the old American candle-power to the International candle-power. The effect of this change from the British unit of 1.6 per cent. in the unit of the Bureau of Standards, which is in general use for electric lighting throughout the country is to raise the candle-power rating and increase slightly the w.p.c. of electric lamps. A 16-candle-power lamp will give 16.26 candles in the new unit, or a 16-candle-power carbon filament lamp burning at 110 volts will give 16 candles on the new basis at 109.69 volts. The change though small is important in the photometry and rating of lamps.

Another recent change is what is known as the 3-voltage plan. The incandescent lamp manufacturers have recently made a radical change in their method of rating these "Mazda" lamps, in order that the lamps could be used with greater economy under those certain conditions where heretofore their cost of operating exceeded that of a less efficient type of lamp and is most valuable in cases where the cost of electrical energy is low. The new method of rating, called "The Three-Voltage Plan," is based upon the fact that for any given set of conditions, depending upon the cost of energy and cost of lamp there is one particular efficiency and life at which it is most economical to operate a given lamp.

Each "Mazda" lamp is labelled with three voltages, two
114
volts apart, as, for example, 112, called top, middle and bottom
110
voltages. This method of rating makes it possible for a customer to select the particular efficiency of lamp he wishes to use by specifying that either the top, middle or bottom voltage, as the case may be, should be the same as that of his lighting circuits.

When burned at top voltage the "Mazda" lamp has the highest efficiency or consumes the least energy for the light produced, and gives life of 1000 hrs. At middle voltage more energy is consumed per candle-power produced and the life is lengthened (due to operation at a lower temperature) to 1300 hrs. At bottom voltage the lamp is operating at the lowest efficiency and gives a life of 1700 hrs. It is obvious that the relative cost of lamp and energy will determine the most economical life and efficiency, since if energy is cheap the saving in energy obtained by operating the lamp at high efficiency is not sufficient to counter-balance the higher resulting renewal expense. On the other hand, if the energy is relatively expensive then it will be desirable to operate the lamp at a high efficiency, since the saving in current at the higher rate will more than pay for the increase in renewal expense.

The efficiency of the different sizes of lamps at top voltage is not the same, since the larger lamps are relatively longer lived than the smaller ones, and, in order to give all sizes a uniform life of 1000 hrs. at top voltage it was necessary to operate the 25-watt. lamp at 1.33 w.p.c., the 40-watt at 1.25 w.p.c., the 60-watt at 100 and 150-watt at 1.20 w.p.c., and the 250-watt and 500-watt at 1.15 w.p.c.

This three-voltage plan was adopted last May by the co-operative companies of the National Electric Lamp Association. Some time prior to this the word "Mazda" was agreed to by the companies forming the National Electric Lamp Association along with others as a word which will accompany the highest efficiency lamp that is made. At the present time the "Mazda" lamp is composed of tungsten filaments or some at present unknown filament which would result in a lamp of higher efficiency than the present tungsten filament lamp, it would be the "Mazda." "Mazda," therefore, is the hall-mark of quality and progress in high efficiency metal filament lamp manufacture, or the seal of the world-wide co-operative effort to produce the best.

A great many people seem to think that illuminating engineering and the different phases of work in connection therewith is narrow, but the "Mazda" lamp and its importance from an invention standpoint shows the broad field there is for the illuminating engineer.

To show its real value, let us consider a steam turbine, electric system and note the great loss in conversion of energy from coal to light.

From Fig. 25, we start with coal containing 100 per cent. energy. Consider boilers working at an efficiency of 70 per cent.

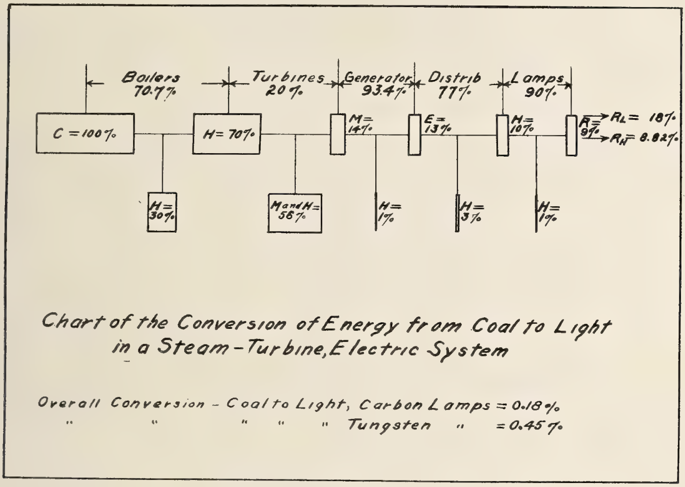

Boilers 70.7%
Turbines 20%
Generator 93.4%
Distrib 77%
Lamps 90%
C = 100%
H = 70%
M = 14%
E = 13%
H = 10%
R = 9%
R_L = 18%
R_H = 8.82%
H = 30%
M and H = 56%
H = 1%
H = 3%
H = 1%
Chart of the Conversion of Energy from Coal to Light in a Steam-Turbine, Electric System
Overall Conversion - Coal to Light, Carbon Lamps = 0.18%
" " " " " Tungsten " = 0.45%

FIG. 25.

we have 70 per cent. going as useful energy to the turbines and 30 per cent. wasted as heat loss. Turbines at an efficiency of 20 per cent., we have 14 per cent. going to generations and 56 per cent. wasted in overcoming mechanical resistance and heat loss. Generations at the efficiency of 93 per cent., we have 13 per cent. going to the distributing system and 3 per cent. wasted. Distributing system 77 per cent. efficient, we have 70 per cent. going to the lamps and 1 per cent. wasted. Lamps 90 per cent. efficient, we have 9 per cent. of the 100 per cent. started with, as radiant heat and light therefore we have only 18 per cent. of what we started with a light when carbon lamps are used. Now let us substitute "Mazda" lamps, and, considering their relative efficiencies as carbon, 3.1 w.p.c. and "Mazda" 1.25 w.p.c., we would have 45 per cent. instead of 18 per cent. This remarkable triumph in the science of light can be further shown by imagining an almost impossible accomplishment, that is the invention of a turbine working at an efficiency of 50 per cent. Now, if such were the case, 3 per cent. of the original energy would go to the generators instead of 14 per cent. and considering the rest of the system the same as before there would be 32.5 per cent. available for the distributing plant and 25 per cent. would be radiant heat and light; we have 45 per cent. of the original 100 per cent. available for light when carbon lamps are used. Among mechanical engineers it is hardly expected that the existing efficiencies in machines will improve to a very great extent, therefore, the "Mazda" lamp is equivalent to an imaginary turbine of 50 per cent. efficiency and consequently opens a new field in the realms of engineering, and when we look back and find the carbon lamp has been improved from 6.5 w.p.c. to 2.5 w.p.c. in the Gem (which is an improved carbon filament), it is hard for one with a most vivid imagination to forecast its future when it starts at excellent efficiency of 1.25 w.p.c.

The following table shows comparative costs for obtaining 80 candle power from Carbon, Gem, Tantalum and "Mazda" lamps. At the present electric power rates, a large saving is noted in favor of "Mazda" lamps. At a power rate of 10c per kilowatt hour the cost for 80 candle power of "Mazda" light for 1000 hours burning (which includes the lamp cost) is about three sevenths of the actual cost of power alone for equal candle power from carbon lamps of 3.5 w. p. c.

Designation			**Carbon**		**Gem**	**Tantalum**	**Mazda**
Watts per Candle—Actual			3.5	3.1	2.5	2.0	1.25
Size of Lamps			16 c. p.	16 c.p.	40 c. p.	40 c. p.	80 c. p.
No. of Lamps Compared			5	5	2	2	1
Total Candle Power			80	80	80	80	80
Watts per Lamp			56.0	49.6	100	80	100.0
Total Watts for 80 c. p.			280	248	200	160	100
Hours Useful Life—Each			830	450	460	800	800
Cost of Lamps			$ 1.00	$ 1.00	$ 0.70	$ 1.70	$ 1.75
Cost of Renewals, 1000 Hours			1.205	2.22	1.474	2.126	2.188
Cost of Power per K.W.H.	.01	Table of combined cost of Power and Lamp Renewals for 80 c. p. for 1000 Hours	4.005	4.70	3.474	3.726	3.188
	.02		6.805	7.18	5.474	5.326	3.188
	.03		9.605	9.66	7.474	6.926	5.188
	.04		12.405	12.14	9.474	8.526	6.188
	.05		15.205	14.62	11.474	10.126	7.188
	.06		18.005	17.10	13.474	11.726	8.188
	.07		20.805	19.58	15.474	13.326	9.188
	.08		23.605	22.06	15.474	14.926	10.188
	.09		26.405	24.54	19.474	16.526	11.188
	.10		29.205	27.02	21.474	18.126	12.188
	.11		32.005	29.50	23.474	19.726	13.188
	.12		34.805	31.98	25.474	21.326	14.188
	.13		37.605	34.46	27.474	22.926	15.188
	.14		40.405	36.94	29.474	24.526	16.188
	.15		43.205	39.42	31.474	26.126	17.188

The foregoing table shows comparative costs for obtaining 80 candle-power from Carbon, Gem, Tantalum and "Mazda" lamps. At the present electric power rates, a large saving is noted in favor of "Mazda" lamps. At a power rate of 10 cents per kilowatt hour the cost for 80 candle-power of "Mazda" light for 1000 hours' burning (which includes the lamp cost) is about three-sevenths of the actual cost of power alone for equal candle-power from carbon lamps of 3.5 w.p.c.

The chief objection to the tungsten filament lamp is its fragile nature, but this is certain to be overcome when we notice the same objections were made about the carbon lamp about fifteen years ago. I feel safe in predicting a much higher efficiency for the "Mazda" lamp and a perfecting of the strength of the filament to stand any reasonable amount of jar and rough usage.

DRY CELLS.

SAUL DUSHMAN, B.A.

At a meeting of the American Electro-Chemical Society in October, 1909, the following remarks were made by President Baekeland:

"The dry cell, modest as it may appear as a unit, forms the base of a more important industry than most of us imagine. The number of dry cells consumed yearly can be counted by millions, the industry is more important than many electro-chemical industries of which we hear much more in our meetings, and read more in print. It so happens, at the same time, that it is one of the subjects on which a very large amount of misinformation is abroad, misinformation sometimes sent out purposely, but most of the time involuntarily through pure ignorance. It is almost impossible to tell beforehand whether a dry cell is good or not, because here everything goes by experience. In fact, I would almost say that the test of a dry cell is to use it for a particular purpose. We are familiar with the phrase 'the test of the pudding is in the eating of it,' but the trouble is that after the eating of the pudding there is none left."

This statement, taken together with the fact that the annual production of dry cells in the United States alone is well over the 50,000,000 mark, shows the importance of a more perfect knowledge of the behavior of dry cells than is at present possessed by the great majority of users.

Construction of Dry Cells.

Probably 80 per cent. of the dry cells made and used are of the so-called No. 6 size, about 6 inches high and 2.5 inches in diameter. A cylindrical zinc container, insulated externally by cardboard, acts as negative pole, while the positive consists of a carbon rod or plate. The zinc can is lined with "an insulating absorbent layer, which serves as a reservoir for electrolyte and as a means of separating the two electrodes. This layer is usually made of a special grade of pulpboard manufactured for the purpose under conditions that prevent the presence of ingredients harmful to the cell." The filling material is packed in between the zinc container and the carbon electrode. A fairly typical filling-mixture has the following composition:

10 parts manganese dioxide (MnO_2),
10 parts carbon or graphite,
2 parts sal ammoniac (NH_4Cl),
1 part zinc chloride ($ZnCl_2$).

Water is added to make a heavy paste and to produce the requisite electrolyte.

Chemical Reactions.

When the cell is discharging the solution of $ZnCl_2$ and NH_4Cl is decomposed by the current; the chlorine liberated at the anode attacks the zinc and forms more $ZnCl_2$, while the hydrogen gas which would otherwise dissolve in the carbon and produce a back e.m.f. is "depolarized" by the MnO_2. The latter is reduced in this process to a manganous salt. The increase in the total amount of $ZnCl_2$ in the cell as well as the decrease in available MnO_2 lead to a gradual diminution in the electromotive force of the cell. The addition of the $ZnCl_2$ to the filling mixture might appear, therefore, to be a questionable procedure. Nevertheless, it has been stated that this addition is necessary.

As the rate of the chemical reactions at the electrodes is always proportional to the rate at which current is taken out of the cell (Faraday's Law) it is readily seen that fresh chemicals must continually replace those used up at the immediate surfaces of the electrodes.

If current is drawn out of the cell at a rate greater than that at which the fresh chemicals can diffuse in towards the electrodes, the electromotive force begins to drop very rapidly, and the cell is said to be "polarized." It follows that the larger the surface of the zinc and the more finely pulverized the manganese-dioxide carbon mixture, the greater the current that may be taken out of the cell without polarizing it. Furthermore, the more homogeneous the mixture, the more rapidly the cell will recover from the effects of heavy currents.

Voltage and Capacity.

The open-circuit voltage varies in different types from 1.5 to 1.6 volts, and is on the average 1.56 volts. The electrical energy output varies greatly with the manner in which the cell is used. When short-circuited an average cell will give from 18 to 25 amperes, falling at the end of one hour to 10 amps. at about 0.5 volt. It is, however, a serious mistake to consider this short-circuit current a measure of the value of a cell. As a matter of fact it often happens that cells which give a high short-circuit current fail badly when tested by the standard of service-capacity, that is, by the number of ampere-hours delivered when the cell is discharged through a resistance of 16 ohms. The following table, taken from Ordway's paper, illustrates this point:

TABLE I.

Short-circuit Current and Service Capacity of Dry Cells.

Brand of Cell.	Short-circuit Current.	Service Capacity.
A	33.0	24.0
B	29.5	46.0
D	24.5	33.5
G	22.5	40.0
J	20.9	18.2
L	20.2	36.0
Q	19.2	38.6
S	18.2	27.1
W	9.7	16.0

An important fact about dry cells is that the service-capacity, as well as the short-circuit current, drops even when the cell is standing on open circuit. This drop in the short-circuit current is known as the "shelf-life" in the trade, and although in itself the short-circuit current may be of no value as a measure of the efficiency of the cell, yet a considerable variation in this current given by an old cell and that given by a new cell is a sure indication of a serious fault in the mechanical construction of the cell.

The energy output of a dry cell depends upon the conditions under which the cell is discharged. The discharge may be either continuous or intermittent, and in the usual case it occurs through a constant resistance. The following table, also taken from Ordway's comprehensive paper, represents typical results obtained at the Research Laboratory of the National Carbon Co., Cleveland:

TABLE II.

Watt Hours from No. 6 Dry Cells Discharged Continuously.

End Point in Volts.	Resistance used in Ohms.						
	2	4	8	16	24	32	40
1.2	3.7	4.3	8.1	15.2	18.8	21.7	23.8
1.0	6.7	13.0	16.5	26.9	33.4	39.8	42.0
0.8	9.7	16.3	21.5	32.8	40.3	44.6	50.6
0.6	12.5	19.4	26.6	48.9	49.5	52.7	53.2
0.4	15.4	27.3	39.1	52.6	54.3	58.2	54.8
0.2	19.8	32.6	41.5	53.3	55.2	59.3	57.1

F. H. Loveridge gives the following values of the energy output of dry cells discharged to 0.5 volt:

With 1 ohm	7 watt hours
With 2 ohms	8 watt hours
With 4 ohms	14 watt hours
With 6 ohms	21 watt hours
With 10 ohms	24 watt hours

When discharged intermittently through the same resistances, the cell gives a longer actual service as long as the voltage does not diminish to less than one-third its original value. After this stage is attained the cell can be operated more efficiently on a continuous discharge.

C. F. Burgess carried out a large number of tests with dry cells obtained from eleven different manufacturers. The number of watt hours delivered by the cells on intermittent service varied from 58.4 to 3.3, and the initial resistance from 0.68 to 0.17 ohm. Burgess states that a good dry cell, when used on intermittent service should deliver 2.27 watt hours per cubic inch contents, and should have a resistance not greater than 0.3 ohm.

The Effect of Temperature.

While the effect of increased temperature on the electromotive force of a dry cell is only slight, the effect on the shelf life is very deleterious. Cells which initially give a short-circuited current of 20 amperes will indicate a current of less than 1 ampere when stored for several months at a temperature of 50° C, while the same cells stored for an equal length of time at ordinary temperature will indicate 18 or 19 amperes. This accounts for the advice of manufacturers that dealers and users store their cells in a cool place.

" The service capacity of dry cells may be either increased or decreased by raising the temperature according to the conditions under which the cells are tested. In general, more service of a severe nature will be obtained if the cells be moderately warmed, while with very light service it is advantageous to keep the cells cool. It is dangerous, under any circumstances, to use dry cells at temperature much above 50°C."

Testing of Dry Cells.

The object of a test is to determine the value of any piece of apparatus or material for a certain specific purpose. Such a test may be either comparative or absolute. In the case of the dry cell the first test to be applied was the measurement of the short-circuit current. At the best this could only be a comparative test; but, as pointed out above, the conclusions to be drawn from it are useless as regards the service capacity. The continuous resistance test was therefore tried next. It was soon found, however, that here again the conclusions of such tests were not applicable to conditions in actual practice. While one cell may be superior to another when discharged continuously, yet the reverse may be the case when both cells are tried on the same ignition arrangement. Or two cells may show equal energy output on continuous discharge, but be unequally efficient when used on telephone service. Now the question which obviously interests the consumer is not the amount of energy which the cell is capable of delivering under certain standard conditions, but **the actual hours of service that he may expect to obtain when operating a definite piece of apparatus under definite conditions with the given cell.** The conclusion, therefore, at which both manufacturers and consumers have arrived is to devise tests that shall duplicate as nearly as possible the conditions under which the cells are to be used, thus making it possible to obtain data by which the cells can be rated for a given service.

As the two main uses of dry cells are for telephone and ignition service, we shall briefly review the nature of the tests which have been elaborated to determine the value of a dry cell for either purpose.

(1) Telephone Service.

"To represent as nearly as possible average telephone service, two or three dry cells should be connected in series through about 15 ohms for as many periods each day as there are calls on an average telephone, each period being the length of an average telephone conversation, and the cut-off point being taken as the lowest working voltage that will give satisfactory service."

A simple test may be carried out as follows: Three cells in series are discharged through 20 ohms resistance for two minutes per hour, 24 hours per day, until the working voltage (taken just before the end of a contact) decreases to 2.8 volts. The test may be varied by discharging three cells in series through 15 or 20 ohms for four minutes per hour, 10 hours per day, until the same voltage is attained.

(2) Ignition Service.

"In the usual type of ignition apparatus the battery current passes through the primary of an induction coil at the right instant in the engine's cycle, and by means of a vibrator is made to rise and fall very rapidly, thus producing pulsations of very high voltage in the secondary, and a series of sparks at the spark plug which ignites the explosive mixture in the engine cylinder. The primary of the average induction coil has a resistance of about 0.5 ohm, and if the circuit through the coil were to be closed indefinitely the current would rise to from 12 to 16 amperes, depending on the voltage of the battery used. The action of the vibrator is so rapid, however, that the current does not have time to build up to its maximum value, and the actual initial impulse rises to only three or four amperes." Tests in which actual induction coils were used have been found to be useless owing to the fact that it is almost impossible to keep the coil in permanent adjustment. The following is given by Ordway as a standard test for ignition-cells: "Six cells in series are discharged through 16 ohms resistance for two hours per day, one hour in the morning and one hour in the afternoon. About twice a week the cells are short circuited through a half-ohm coil for a few seconds, and the current flowing is noted. When this current flowing, or impulse, reaches four amperes, the battery is removed from the test, and the life of the battery is reported as the hours of service given under the above conditions to four amperes impulse through a half-ohm coil. A modern dry cell of good quality will give 30 hours of service on this test at ordinary room temperature of, say, 22 to 24° Centigrade."

Conclusion.

It is evident from the above remarks that there is no single test which the manufacturer or consumer can apply to a dry cell to indicate quickly and simply its value. Each application requires special standards of its own, and it is not at all reasonable to expect that the same type of cell will fulfil the requirements of different users.

List of References.

J. W. Brown. The Use of Dry Cells on Ignition Service. Trans. Am. Electrochem. Soc., 13, 172-185.

C. F. Burgess and C. Hambuechen. Certain Characteristics of Dry Cells. Trans. Am. Electrochem. Soc., 16, 97-108.

F. H. Loveridge. Dry Cell Tests. Trans. Am. Electrochem. Soc., 16, 109-124.

D. L. Ordway. Some Characteristics of the Modern Dry Cell. Trans. Am. Electrochem. Soc., 17, 341-366. All the passages quoted above are taken from this paper.

C. F. Burgess. Tests of Dry Cells. Electr. World, 39, 156.

ARCHITECTURAL DESIGN.

The illustrations used in this article are intended to represent the work done by the different classes in the Department of Architecture of the Faculty of Applied Science. Some problems are given to illustrate the nature of the requirements, and the wide scope for the students' original ideas.

The department is in the charge of Mr. A. W. McConnell, who is a graduate of this department of the University, being a member of the class of '06. Mr. McConnell has further spent several years studying design in Paris and has brought back with him a thorough knowledge of the methods of teaching design as practised in the Atelier de M. Gromort.

A large number of the leading architects of this and other cities have visited the Department of Architecture during the present session and have expressed unanimously their approval of the work done by the students in this department. Those who are in the position to know, compare favorably the work in Toronto University with that of similar departments of American universities.

Applied Science understands the encouragement that such appreciation has for the students in architecture, and hopes other members of the profession will pay visits of inspection to their studios in the Engineering Building.

Following is a list of problems that are typical of those comprising the course:—

First Year Problems.

I. Survey of Building.

The student is asked to make measurements of a building or part of a building in his regular course of surveying and represent the same in plan, section and elevation in his studio. (See Plates II. and III.)

II. Orders of Architecture.

Arrangement of plates in it, using the various orders of architecture. (See Plates IV. V. and VI.)

Second Year Problems.

I. Porch for City Residence.
(See Plate VII.)

II. A Small Public Library.

The student is asked to make sketch plans in the class-room, and to work out the problem in plan, section and elevation in the studio, developing his original idea. (See Plate VIII.)

Third Year Problems.

I. A Dispensary for Children.

(See Plate IX.)

II. A Railway Station for Suburban Line.

This building is to be erected in a suburb of a large city facing a bridge over a viaduct on a busy thoroughfare. The line passes 25 feet below the street level. The building will not exceed 80 feet frontage.

The following accommodation is required:—

- (a) Large hall.
- (b) Two ticket offices.
- (c) Station master.
- (d) Baggage rooms with elevators for both lines.
- (e) Newspapers, etc.

(See Plate X.)

III. A Small City Hall.

(See Plate XI.)

IV. Music Hall.

This building is to be erected in a public park in a city of 40,000. The front elevation is not to exceed 80 feet in length. Concerts will be given day and night.

Required—

- (a) Vestibule with ticket offices.
- (b) Porticos, also to be used as a shelter for the people in the park.
- (c) Auditorium with seating space for 400.
- (d) Stage for 50 musicians.
- (e) Library for music.
- (f) Lobby for artists.
- (g) W. C., etc.

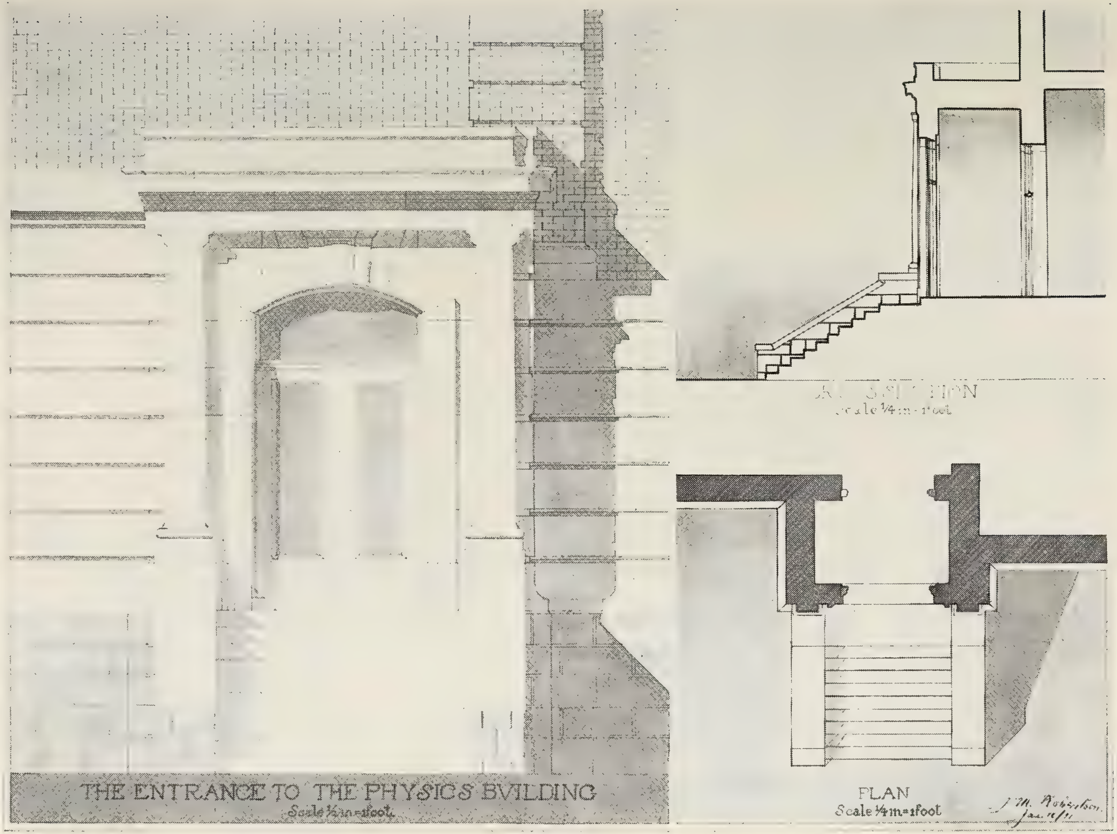


PLATE II.
Measured Drawing by J. M. Robertson.
(See First Year Problem I.)

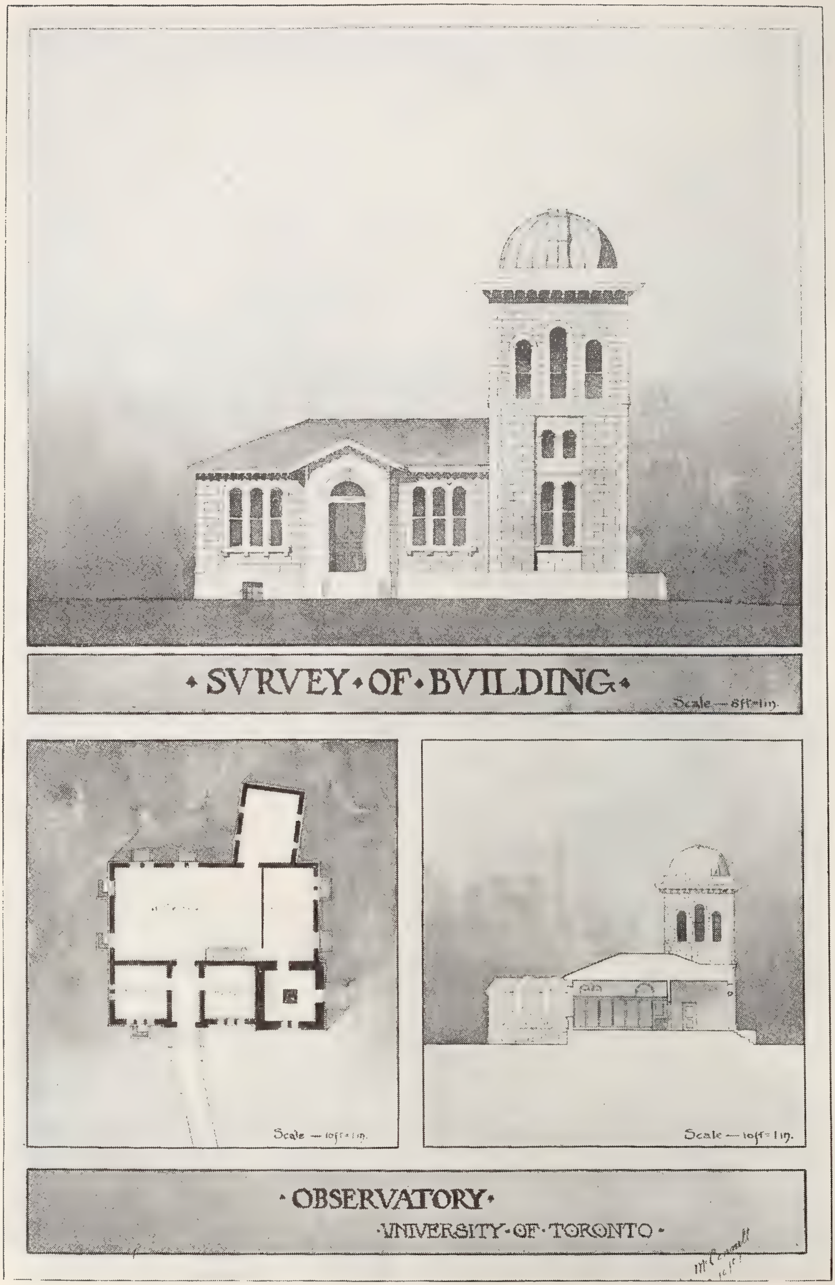


PLATE III.
Measured Drawing by R. S. McConnell, '13.
(See First Year Problem I.)

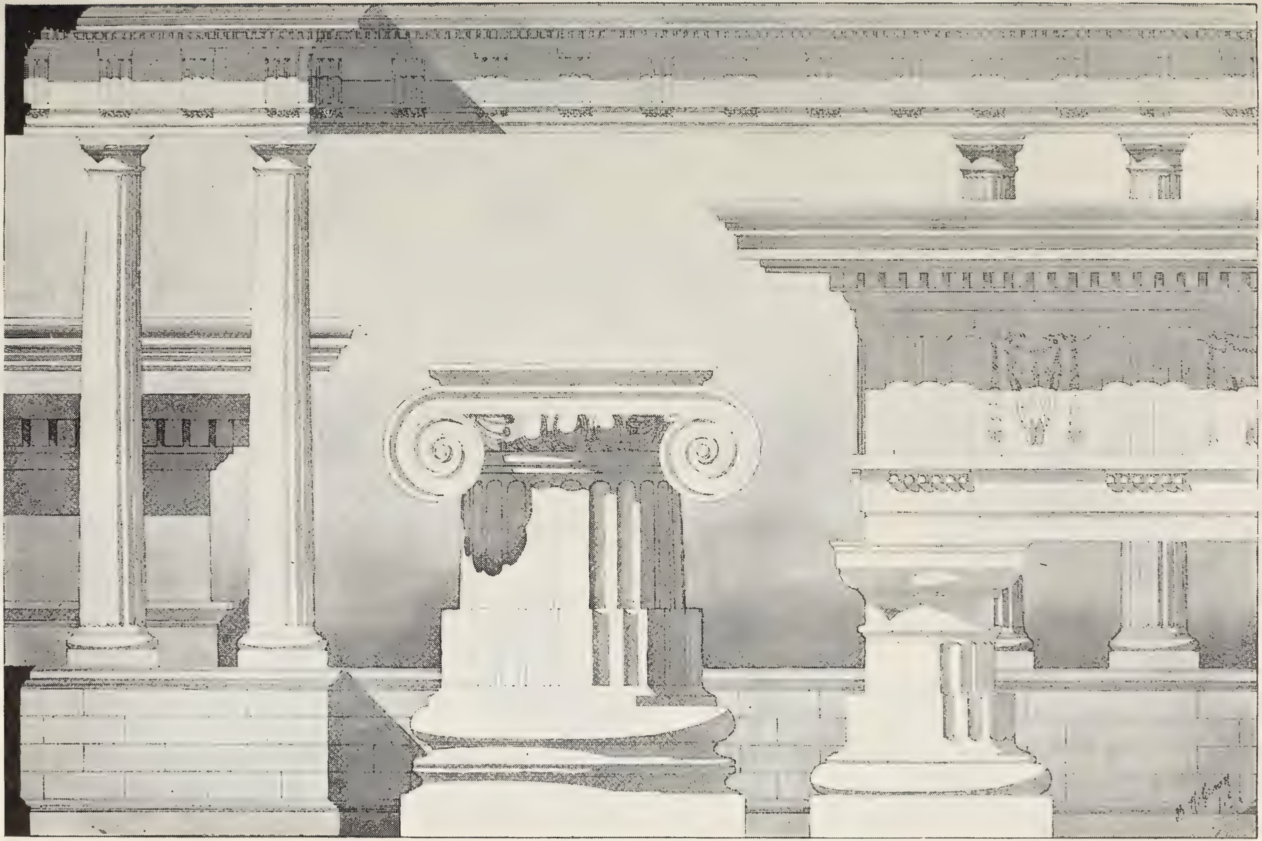


PLATE IV.
Designed by B. R. Coon.
(See First Year Problem II.)

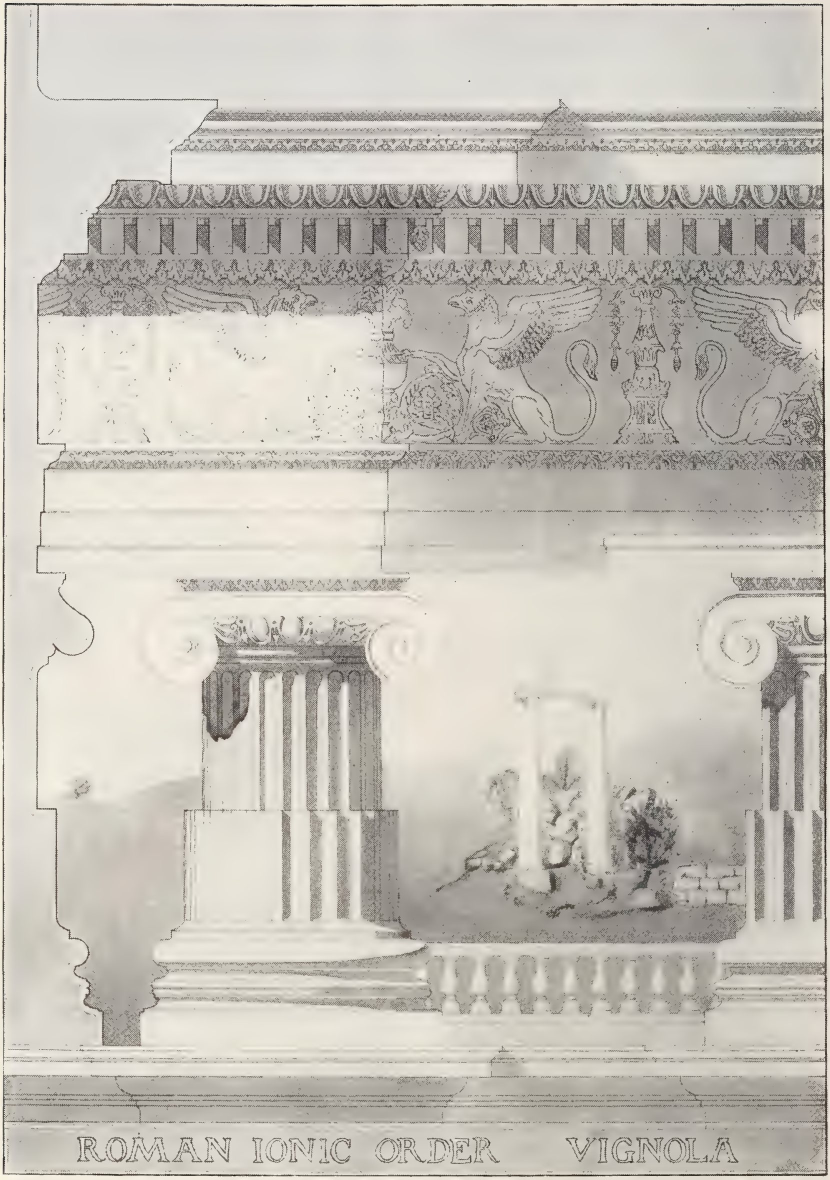


PLATE V.
Designed by R S. McConnell, '13.
(See First Year Problem II.)

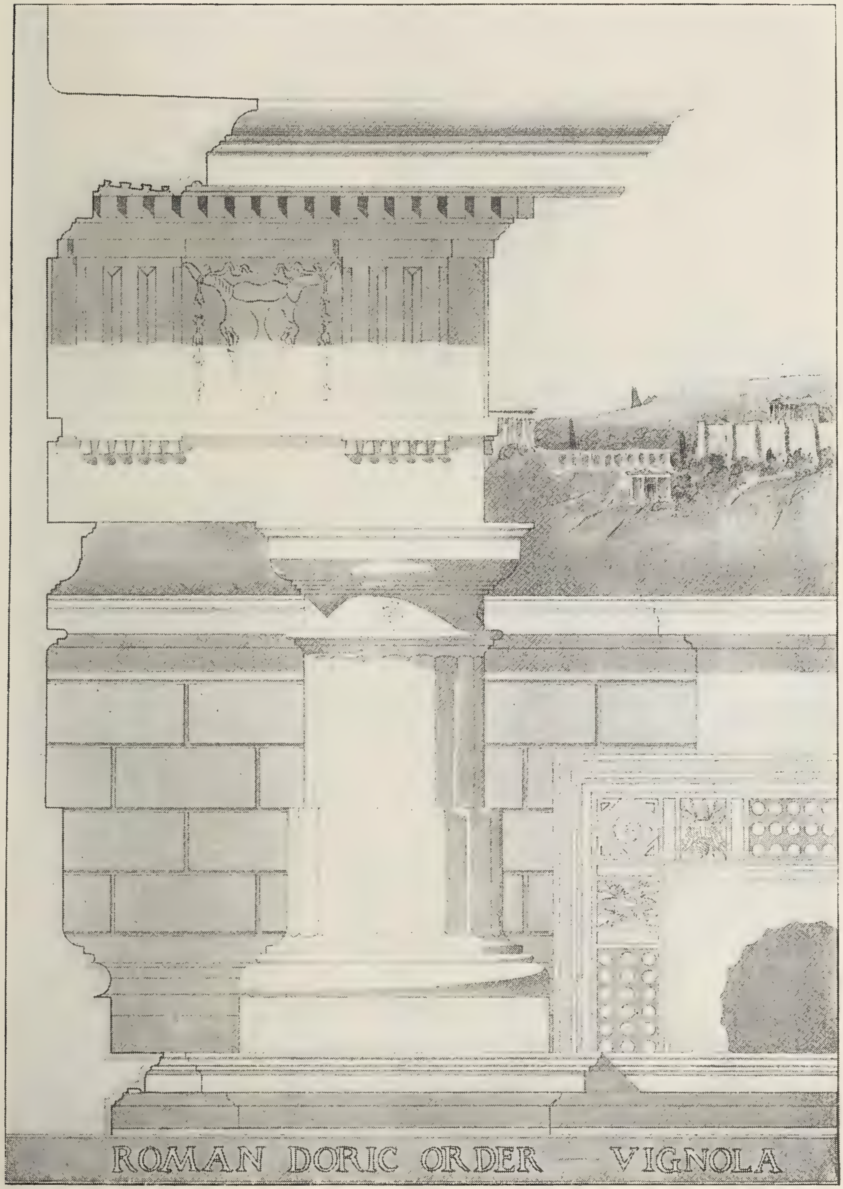
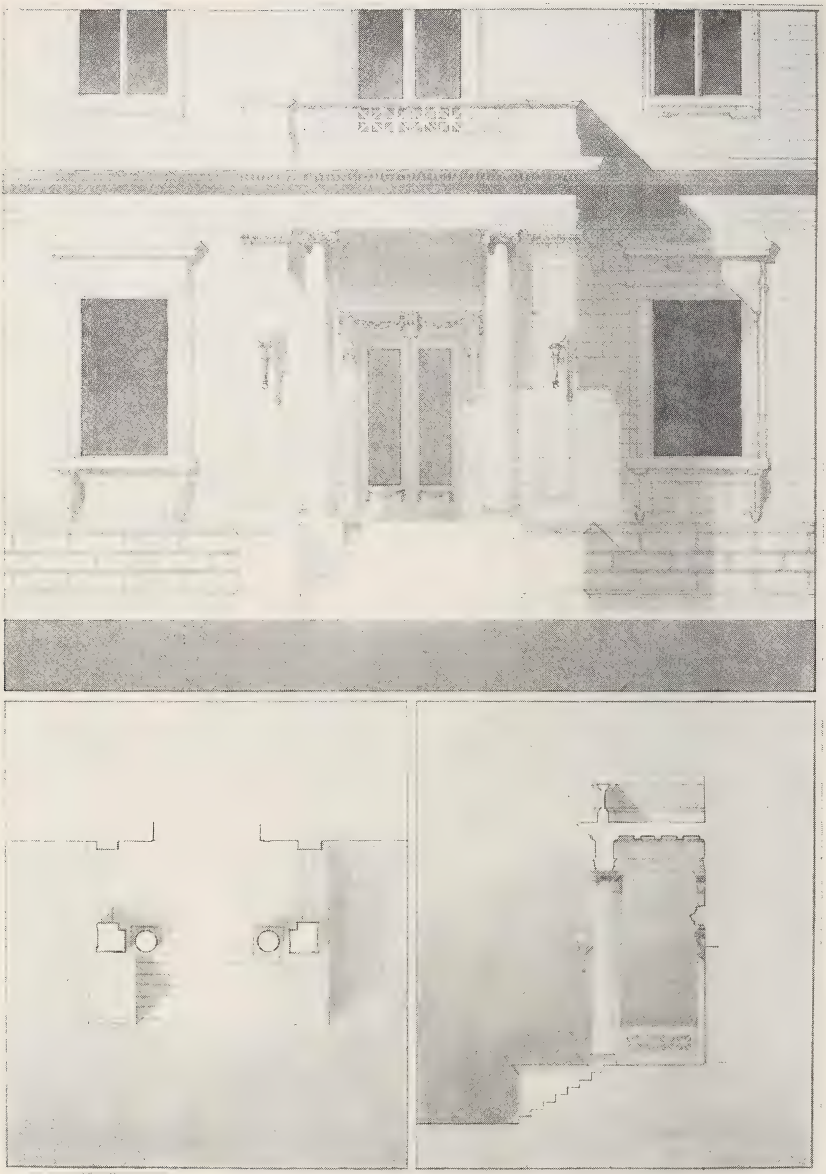
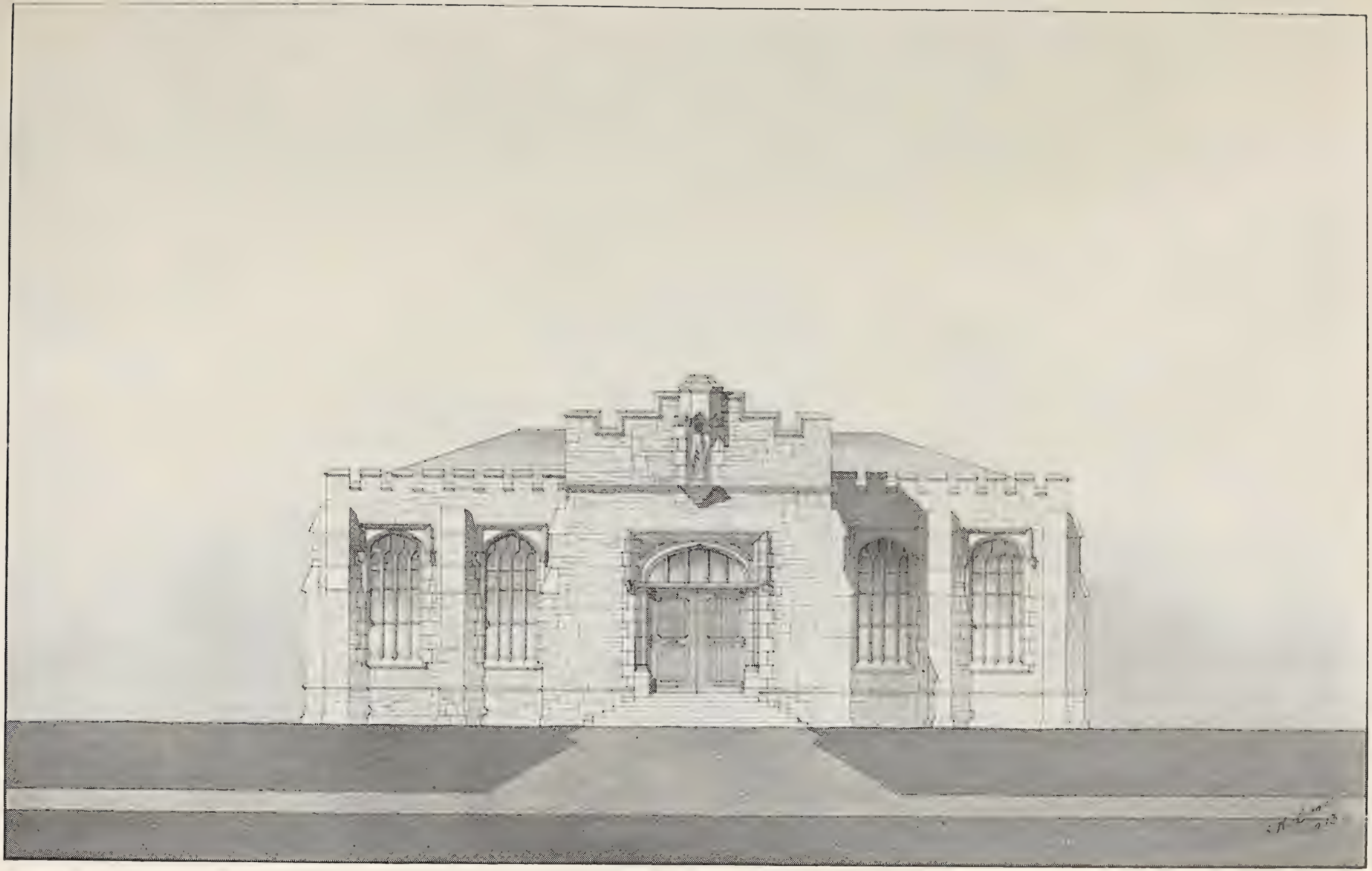


PLATE VI.
Designed by R. S. McConnell, '13.
(See First Year Problem II.)



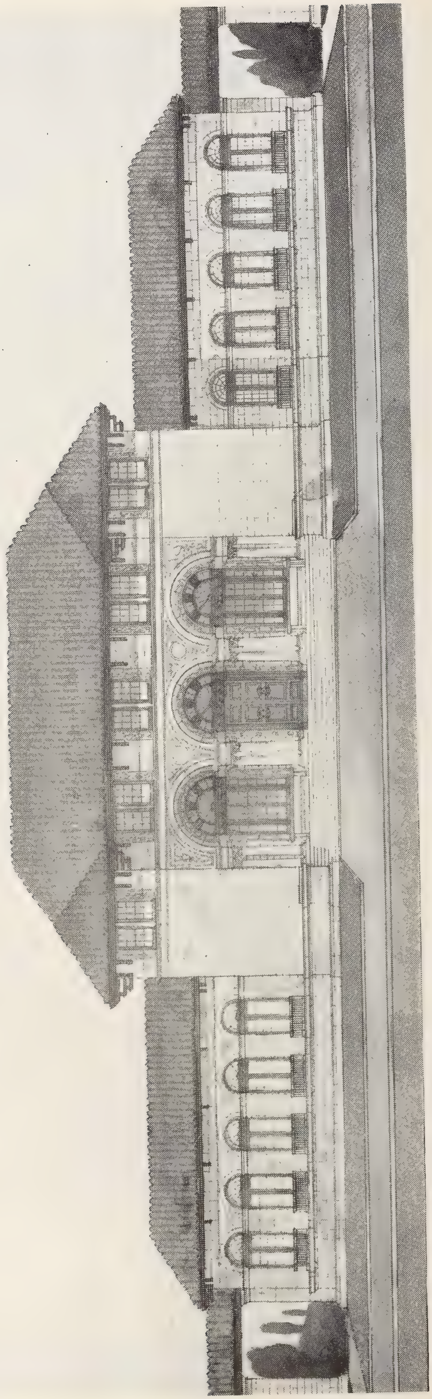
Porch for City Residence.

PLATE VII.
Designed by H. H. Madill, '11.



A Small Public Library.

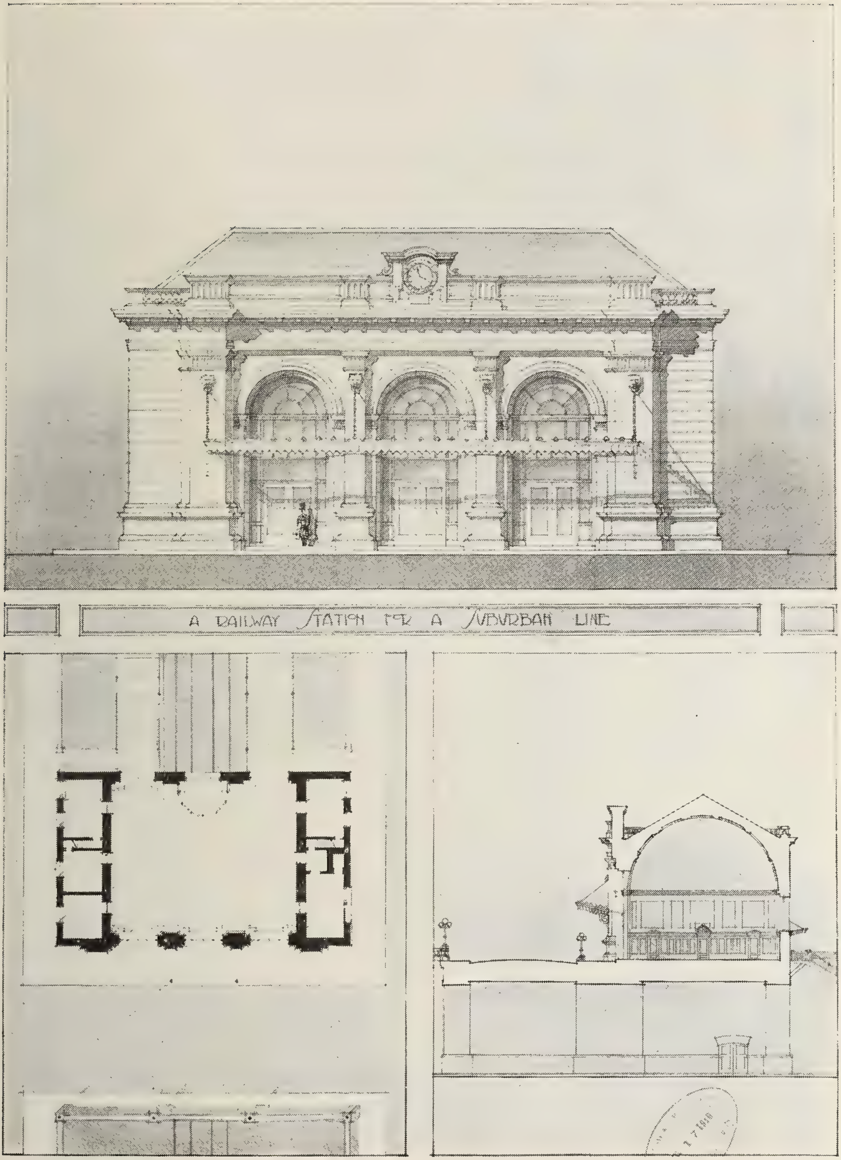
PLATE VIII. Designed by B. R. Coon
(See Second Year Problem II.)



A Dispensary for Children.

PLATE IX.

Designed by J. B. K. Fisken.

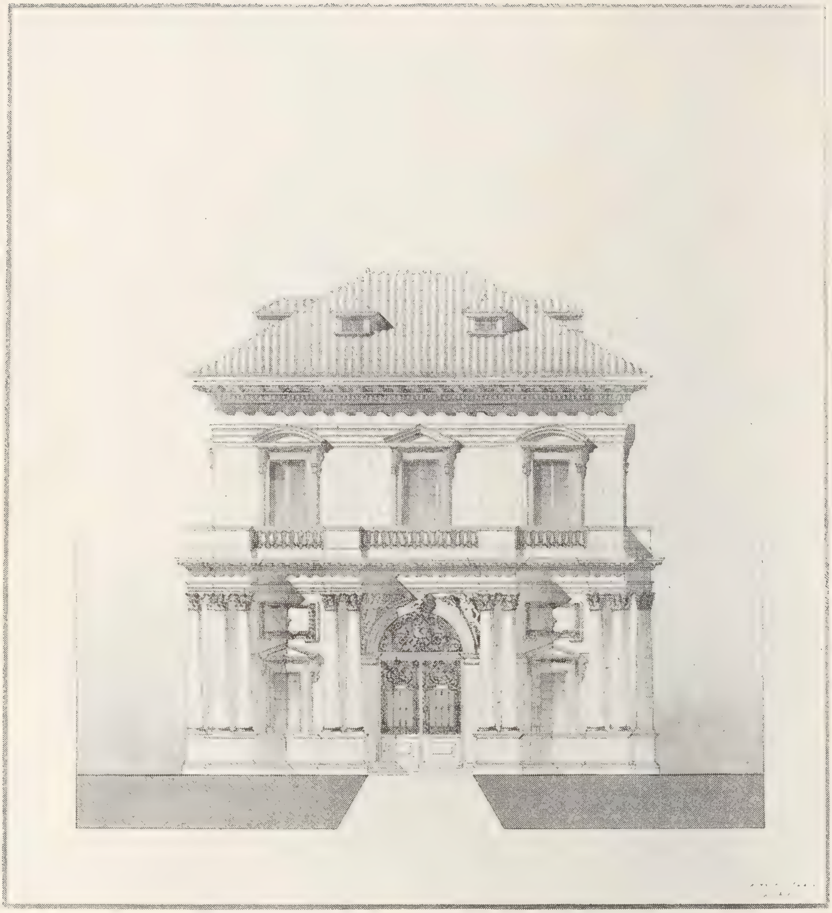


A Railway Station for Suburban Line.

PLATE X.

Designed by H. H. Madill, '11.

(See Third Year Problem II.



A Small City Hall.

PLATE XI.

Designed by T. L. Rowe.

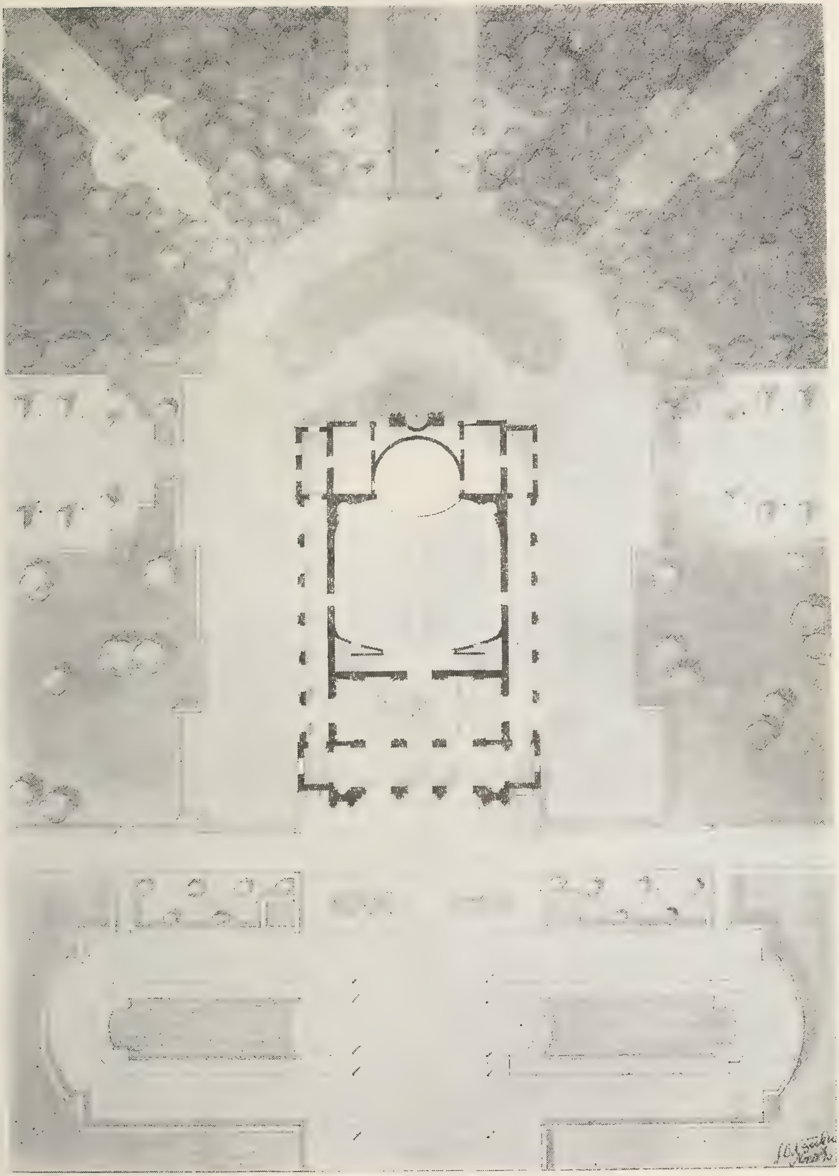
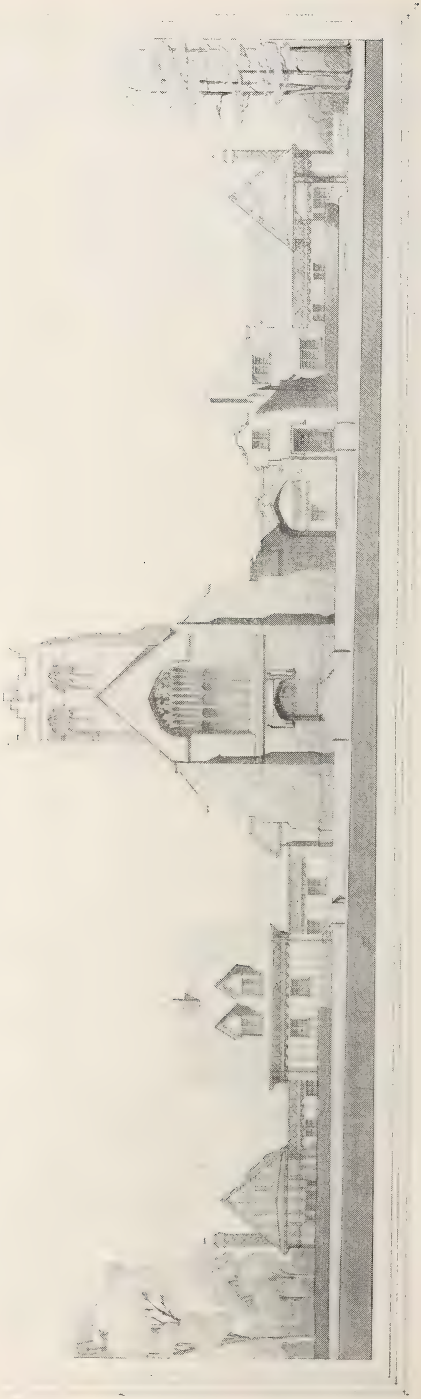


PLATE XII. Music Hall.
Designed by J. B. K. Fisken.
(See Third Year Problem IV.)



A Home of Rest for the Aged Poor, with detached Chapel and Manse.

PLATE XIII.

Designed by H. H. Madill, '11.

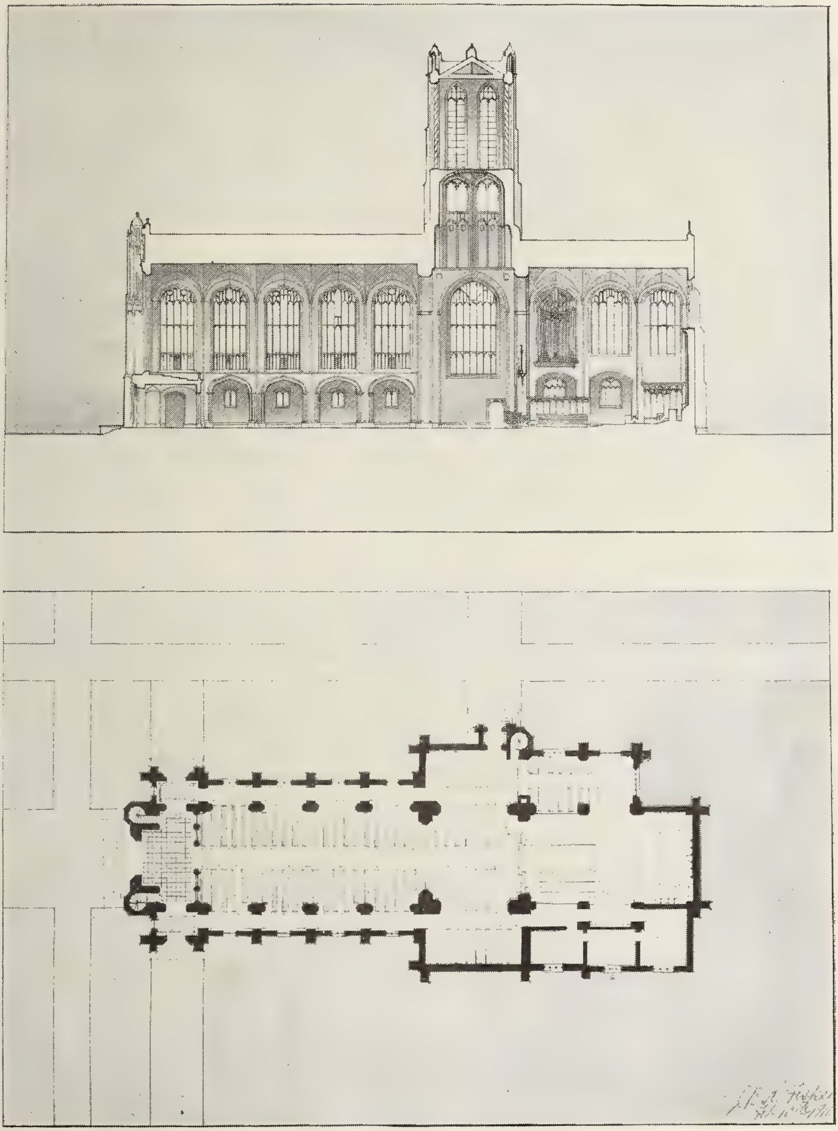


PLATE XIV. A Gothic Church.
Designed by J. B. K. Fisken.

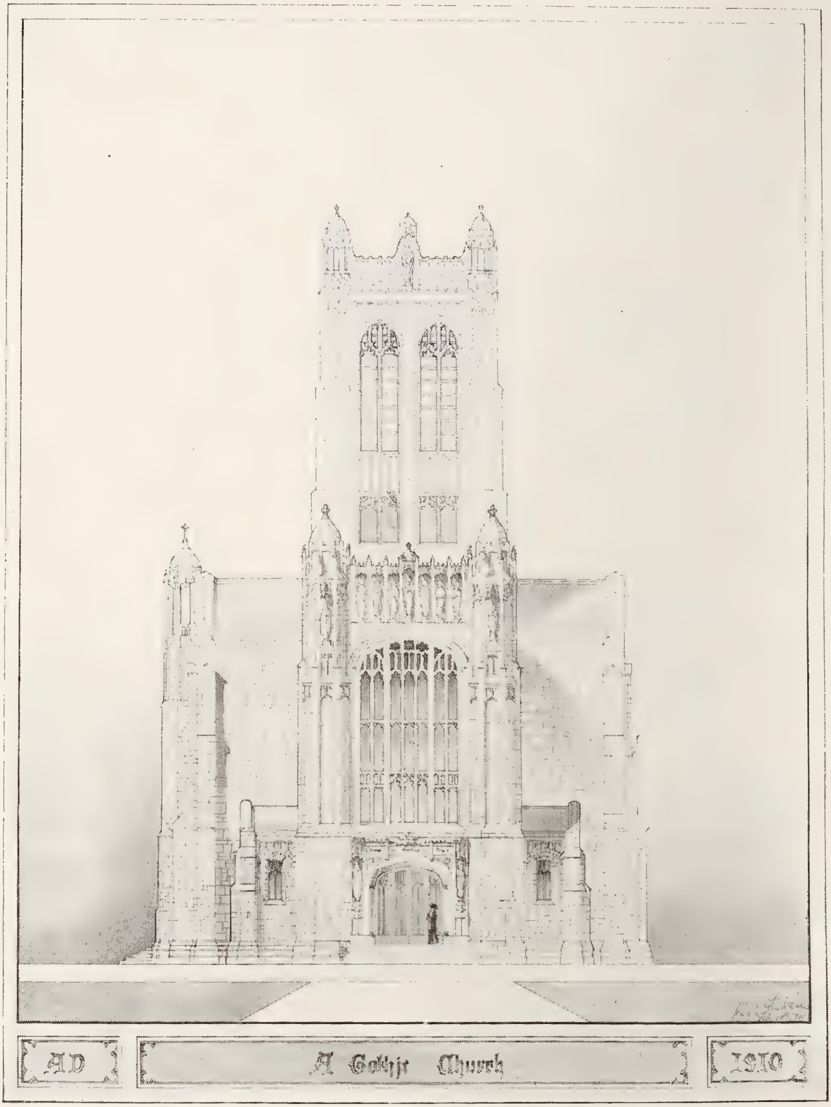


PLATE XV. A Gothic Church.
Designed by J. B. K. Fisken.

THE ENGINEERING SOCIETY DINNER

The twenty-second annual banquet of the Engineering Society has been added to its list of predecessors as a success from every point of view, and the executive upon whose shoulders the responsibility was placed are reaping a reward of praise for their untiring efforts.

To undergraduates the dinner has been a yearly opportunity to assemble as one of the strongest organizations of its kind, to meet the graduates of previous years, and to listen to men who, as statesmen, are at home when in the midst of plans and conceptions for the material betterment of Canada; and who endeavor to impress upon the undergraduates that it is they, as engineers, in whose hands the carrying out of these plans will be placed.

To graduates, the banquet is a reunion, a rendezvous of old classmates and instructors, and the founding of an acquaintance with those who are preparing to assist them in the building of productive transportation and commercial economy, and in the managing of material affairs in general.

To those who come as the guests for the evening, the dinner gives an idea of the magnitude of this Faculty of the University, of the student " esprit de corps " that is so necessary to its advancement, and of the forces behind it all, the forces to which many of the most successful engineers in America claim they owe a great deal and feel proud of, and on which the student to-day relies so much.

What is being accomplished in the Faculty of Applied Science and Engineering has been regrettably unknown to the majority of statesmen, unless they happen to be engineers, or have been in contact with the graduates. But the methods employed, the equipment used, and the needs of both these factors, to operate on the ever-increasing scale cannot be brought to their attention unless they become interested in the profession of engineering in general. The annual banquet of the Engineering Society accomplishes a very great deal toward this end.

Upwards of six hundred were present on the evening of January 19th in Convocation Hall. Mr. A. D. Campbell, the President of the Society, officiated as toastmaster. In welcoming the members of the Toronto Board of Trade as guests of the evening he dwelt briefly upon the fact that some of their interests ran along the same or parallel lines with many of our own future interests. He extended to all, on behalf of the Faculty and its students, an invitation to visit our buildings and equipment, and to study what is here being accomplished for and by young men.

Mr. L. E. Jones, '11, was called upon to propose the toast to "Canada," and coupled with it the names of Dr. Robertson,

The Twenty-second Annual Dinner.

Chairman of the Royal Commission on Technical Education, and Major Leonard, of the Board of Governors. In reply Dr. Robertson spoke as follows:

Dr. Robertson.

Mr. President, Dr. Falconer and Gentlemen,—I thank you, on behalf of the Royal Commission on Industrial Training and Technical Education, for the honor and pleasure of being one of your guests to-night and, for myself, for the honor and privilege of speaking briefly to the students in the Faculty of Applied Science in such a great institution as the University of Toronto.

Canada is becoming a great country, while still a comparatively young country. We older men like to be associated with youth. That helps to keep us young in outlook and in faith. The young in heart, the clear in mind with trained abilities and spirits animated by goodwill, are needed for the upbuilding of Canada. Here you have a good place for training. Teaching is not the whole of training, and telling is only a small part of teaching. The other day in New York I had a talk with two men eminent for their labors and gifts towards the improvement of technical and professional education. Referring to the recent bulletin issued by the Carnegie foundation it was confirmed that the University of Toronto stands in the very front in its physics and engineering departments, and that its splendid equipment was cared for and used with an efficiency not surpassed by any other institution which prepares men for the profession of engineers. Canada is a big place with great possibilities. It needs big men trained to cope with them and make the most of them for the benefit of all the people. The big tasks cannot be undertaken with hope of good results unless men and women of native talent are trained for the work."

In referring to the enormous extent of Canada and its vast, varied and valuable natural resources, Dr. Robertson said that conservation of resources does not mean keeping them out of use. It calls for their development by the application of scientific methods directed by capable men. That makes it possible not merely to pass on to our successors the natural resources unimpaired and undiminished by waste, but actually improved and extended by intelligent management. Competent engineers are needed more and more for all that.

Dr. Robertson gave an outline of the work of the Commission on Industrial Education. Its mission was to enquire, to gather information, and not to propose policies or advocate systems. In its survey of Canada it had already heard the testimony of some thirteen hundred men and women; it had among its witnesses such men as Dr. Falconer, the honored and beloved President of the University, and also men and women who worked at benches and on machines for daily wages. There was agreement in the desire expressed from all sides that Canadians should be industrially efficient; and efficient for all the duties which came to them as workers, as citizens, and as men and women. Trained leaders are no less required than skilful workers. Intelligence, practical ability and goodwill, are needed all through the population, in the ranks with the staff and most of all at "headquarters."

After referring to the production of wealth from natural resources by farming, mining, fishing, lumbering and manufacturing, Dr. Robertson spoke of the essential partnerships which exist between the dieffrent localities and provinces of the Dominion. "We have seen nothing in our survey of this country which indicated that the progress and prosperity of any locality was made to the injury of the others. We are partners as provinces and partners in serving Canada in the various occupations which we follow. Men on the football field strive for the supremacy, for winning in the game. But members of competing teams are not hostile to each other. They are friends and supporters of the game. Team play is the best play for the individual as well as for the team. In the national game of playing for the greatness and goodness of Canada among the nations the same holds good. We must inspire the newcomers, the stream of foreign blood pouring into our citizenship, with the same spirit. They are not only among us, they are of us. Our safety and their welfare are not to be ensured by aloofness or separations or disparagements, but by helping them up to our standards of fair play, by playing the game that way ourselves.

Dr. J. W. Robertson.

Particularly by means of education we must bring them up to our plane and aim higher ourselves. We must teach them to love and serve Canada, and example is here stronger than precept. You young men particularly, who are among the elect in opportunity, as shown by your attendance at this University, must set an example of clean living and clear thinking, and hard work with good will. Thus, you can extend the blessings of your heritage of blood and opportunity for the glory of Canada, and the good of your fellow-citizens throughout the whole land."

Major Leonard spoke briefly, basing his remarks upon the amazing advance Canada has made during the past decade. He emphasized Dr. Robertson's advice to undergraduates to endeavor to realize the responsibility that rested with them.

"Our engineers must be trained for the work they must do. They must be trained to meet the problems of transportation, for instance. We already have great railroads and canals. We are building greater railroads and greater canals.

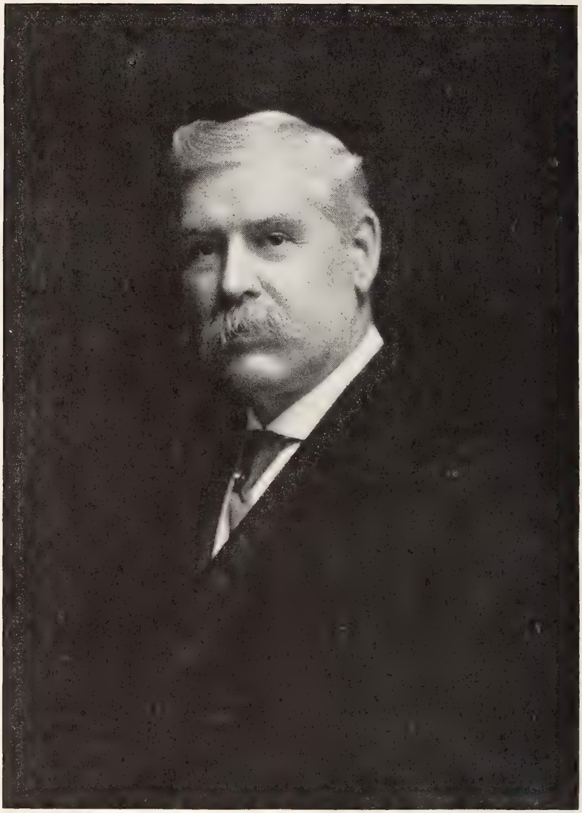
" The passing generations have called to our country many aliens who are now living here with us. The coming generation of engineers will employ many of these aliens, and you men must bring their ideals up to the high plane of your own. Your duties are greater than the duties of those who have built the great railroads and canals, and brought these aliens into our country. Many of these men have come from parts of Europe where they know nothing of responsibility to government such as we know. It is for you to uplift their ideals.

" I was very glad to hear Mr. Jones refer to military training, and of the manner in which the sentiment was received. There is no place where one can acquire executive ability better than in military training, the training whereby a handful of men, such as our Mounted Police, can maintain law and order in such a vast territory as our Northwest, or the preserving of order in India, where a few British troops are surrounded by hordes of semi-hostile people. Such things are possible only by discipline, the discipline which is maintained throughout the entire British army and navy. This is the best school to teach it, and it will be of service to you throughout your whole life."

Mr. R. A. Sara, '09, then proposed the toast, "Canadian Industries," and Mr. R. S. Gourlay, the President of the Toronto Board of Trade, was called upon to reply to this toast.

Mr. R. S. Gourlay.

"You have asked me to respond to the toast of 'Canadian Industries,' and at the outset I would compliment you on the term used. It is not as we hear it so frequently in tariff discussions, ' a few manufacturers,' but Canadian Industries, which cover an area from the Atlantic to the Pacific, which I cannot illustrate better than to give you a picture of my experiences last summer in Kelowna, B.C., where the first manufacturing plant was started last year by a man who had hitherto been simply a grower, and also a little village of 125 inhabitants on the Digby Neck, N.S., which is typical of the whole of Canada. I found there a contented happy settlement, its people engaged in agriculture and fisheries, and the product of the fishery being cured, smoked and packed for the market, even to the making of the cans, whilst, in addition, a buyer purchased another part of the fishing by-product for the export to the United States for manufacture into isinglass, because we have, as yet, no manufacture of this commodity in Canada.



Mr. R. S. Gourlay.

"This, I say, is a picture of the whole of Canada. During the past few years industries have and are being established everywhere so that we now employ in Canada some 445,000 people in these industries, and if we allow a modest estimate for those dependent on them we have easily a million people who are directly supported from these industries, at least one-eighth of our population, without numbering at all the professional, commercial and transportation classes, who also derive the larger part of their incomes from these industries, indirectly it is true, but none the less surely.

"Another thought I would present is that though our industries are making progress, the output last year being estimated at a billion dollars, yet we are as yet only on the highway to being an industrial nation, as our customs imports show us that we imported some $300,000,000 worth of manufactured articles last year, much of which is sold in competition with the same class of goods made in Canada, and the balance because, as yet, we have not entered upon their manufacture.

" For instance, Canada has deposits of silica, yet we make no plate-glass, no window glass and no glass blocks for cutting. Our glass manufactures cover only a fraction of our importation and are confined to bottles, fruit jars, chimneys, globes, and tumblers, with practically none of the finer glass products.

" Again, consider our immense deposits of clay everywhere, and yet beyond building material we only make brick and the common classes of tiles, flower pots, and earthenware, nothing of such table and artistic ware as we use every day, and without which our homes would look poverty stricken if they had to use only made-in-Canada clay products.

"Truly in these classes of industries many lines have not yet reached ' the infant stage,' and so is it in other directions, and there is, therefore, much room for you, young men, who are to go out as leaders and experts in industrial life, to apply your knowledge and see that we make even more rapid progress in the way to becoming a fully developed industrial nation.

" Still another thought—the Government statistics indicate that the relation in Canada between workmen and master is more ideal than elsewhere, in the matter of wages, for the Government statistics show that in Canada much higher wages are paid than in Great Britain and Germany, and wages fully as high are paid in Canada as in the United States, where by the use of larger plants and greater development in specialization the output for the same wage is from 20 to 25 per cent. greater per workman. Whilst a still further indication of this happy, ideal condition between the master and men is revealed in the Government labor reports as to strike conditions. Last year with 445,000 workers there were, small and great, only 68 labor disturbances, affecting 17,000 employees, and that from these if you count out 12,500 employed in mining, building trades and transportation companies, there were but 4,500 people interested in all industries from fishing to street laborers, who, even for a period of a day or two were in any labor trouble, just 1 per cent. of the working force, a record such as cannot be found in any other country under the sun.

" In a word, you are entering on your life labor at a time when Canada is fairly on the highway to being, if not checked, a fully developed industrial nation, with conditions that are at present more ideal than elsewhere, when between master and man there is that spirit of co-partnership that more than aught else will make this country a great industrial nation.

" It is for you, young men, to rightly apprehend and cultivate this spirit, that combined with your skill in specialization and expert trained guidance will so increase the output, augment the workman's wage and the employer's profit as to develop still further this ideal condition.

"I have but one more thought. I am old enough to have begun business at the time when I had to choose between remaining in Canada with limited prospects or to leave for a field of larger possibilities, and I stayed, when the large number of my boyhood friends were finding work to the south of us. The emigration from Canada was enormous, young men of to-day cannot comprehend how enormous, and I also have lived through a period when Canadian industries were so few and far between that Canadian products in my line had to be sold with a guarantee that if they did not please on trial, they would be replaced for the purchaser with American products. But we are past that point, and now the Canadian product is recognized in all parts of the world, as of a class that in point of merit averages a standard that is not excelled in any other country.

" Young men, this fruitage of past years is your heritage, prize it highly, don't part with it, or do aught to lose it. It is your birthright, don't for any temporary advantage become an Esau and sell it for 'a mess of pottage.' "

President Campbell then called upon Mr. L. R. Wilson, '09, to propose the toast " The Legislature." In doing so Mr. Wilson reviewed the interest the Legislative Assembly had taken in the engineering progress of the country, and in endeavoring to further technical education. He made mention of the splendid work the different departments of the Legislature, especially that of Public Works and in the Department of Agriculture.

The Hon. J. S. Duff, in response, expressed his appreciation on the subject of military training for the Canadian boy, and also voiced his intention of watching with interest the great progress of the University, especially of the Faculty of Applied Science.

" The University " was proposed by J. Galbraith, Jr., who likened its success to that of its football teams, and pronounced " team work " as being the mainstay of success in both. He voiced the appreciation of the student body with regard to the magnificent gift of buildings lately presented by the Massey estate.

President Falconer, upon rising to respond, was received with the usual enthusiasm, which bespeaks the place he holds in the hearts of the undergraduates of the Faculty of Applied Science.

President Falconer.

"It was an excellent idea of the Engineering Society to invite here to-night Dr. Robertson, also the members of the Toronto Board of Trade, because many of your will go out and engage in the industries represented by these gentlemen. You engineers must more and more tend to bridge the gap existing between educated men and the class that have often thought themselves to be the unprivileged class, because the privilege of education has been denied to them. You men will come in contact with workmen, and it is through you that some of the benefits of education will reach them. These benefits will enter into the finished product, and also into the life of the man while the product is being brought to its completion.

" Does the engineer work only for the completion of any building or any great work? Ask your graduates in New York whether they sit still and contemplate the building when it is finished. Is that their attitude? By no means. As soon as one piece of work is done they look for another. Enjoyment comes not mainly in the completion but in the process. Day by day you will be putting into the workman the desire to do his work with all his intelligence, and you will be adding to the contentment of his life and to your own happiness. This is the secret of industrial efficiency of the highest sort. To set a high ideal and to realize the ideal is what we aim at in the University and in the Faculty of Applied Science. You are trained to become engineers, but beyond this you must put into the engineering work the purpose of your life, and this cannot be fully reached apart from the development of those who with you carry your engineering designs into execution."

In replying to the toast " The Faculty," proposed by Mr. Chas. Webster, Dean Galbraith commanded the rapt attention of every hearer as he reminiscently reviewed the progress of the " School " since the days, thirty years ago, when Dr. Ellis and himself constituted the teaching staff, and the total enrolment consisted of seven students.

" It would delight the hearts of the founders of this institution and of those who taught here with me first, to see the class which numbered seven when we commenced, grown to nearly eight hundred.

" In the olden days the teaching was done by men from the Colleges. They were well up in their subjects but they had not been out in the world and lacked the contact with actual conditions. One of the great changes has been in the type of men on the faculty. We are cut off from the outside here, and one of the strongest tendencies as a university becomes more immense is to sever the bonds to a greater extent still. It is the duty of our graduates to bring back to us the fruits of their experience in the world with the learning gained here, and to keep us in touch with the outside."

The Dean referred briefly to his recent visit to Cobalt as a guest at the S. P. S. Temiskaming dinner, and praised the work done there by students.

" We are not afraid of lack of success for our graduates, and we are sure of their ability to carry on the work for which they were trained."

Before rising Dean Galbraith was greeted with a chorus from the undergraduates as follows:

" Long live our Dean!
Don't you hear them cheering?
Don't you hear them shouting as the Dean goes by?
Long live the Dean! That's the song we sing,
God bless our Dean! is the students' loving cry."

Mr. W. A. O'Flynn proposed " The Engineering Profession," and coupled with it the name of an old and most successful graduate, W. J. Francis, C.E., of Montreal. The address of Mr. Francis, as that of one student to others, appealed strongly to every student and young graduate present, and could not have been replaced by a more fitting or more appreciated response.

After some humorisms, referring more particularly to school affairs, he quoted Tredgold's historic definition of the Civil Engineer as one who directs the great sources of power in nature to the use and convenience of man. Measured by that standard, the man who employs the electric current to move the wheels of commerce is a civil engineer in the field of electricity; the man who sinks a shaft or drives a tunnel is a civil engineer in the art of mining. The name and the work it implies are most comprehensive and inclusive in their significance. Expressing his great satisfaction that the civil engineer is no longer considered a sort of glorified plumber by the public and that the profession is rapidly taking its place beside those other professions of law, medicine and theology, the speaker made the statement that the reason this condition was so much delayed lay largely with the engineers themselves.

He deplored the practice of many engineers in lobbying for work, and in countenancing the action of individuals and corporations in need of the services of an engineer, who are seeking the lowest bidder regardless of qualifications or reputation. As a parallel between engineers and their clients, he pictured a number of doctors bidding for a surgical operation and the patient in the throes of appendicitis waiting the results of the tenders in order to determine who would do the carving for the least number of dollars.

Proceeding, he spoke of the Canadian Society of Civil Engineers as probably the "greatest professional organization in Canada to-day," and as one which is doing excellent work in elevating the status of the engineering profession, and in endeavoring to create of standard of engineering ethics in Canada. That society, he said, had signally honored the University of Toronto. Dean Galbraith is a past president, and Professor Haultain and many of the other graduates are councillors. A good number of the graduates are members, and the others should all be connected with the Society. Mr. Francis urged the students to affiliate themselves with the Canadian Society of Civil Engineers and so assist in the establishment of a high standard of professional conduct.

Mr. W. J. Francis, C.E.

He referred reminiscently to his student days at Toronto twenty odd years ago, when the staff consisted of Dean Galbraith, Dr. Coleman, and Dr. Ellis of the present staff, and a few others who have since crossed the Great Divide. "We didn't call him the Dean then, we called him Professor—when he was there; you know what we called him when he wasn't there." Those were the days of "the little red schoolhouse" for the engineering student. In the years that have passed since then, great expansion, at that time not even dreamed of, has taken place, but "Five o'clock, gentlemen!" still resounds through the old building. In his closing remarks, he urged the students to master the fundamentals, and to be thorough in their work. He told them they had chosen for their life work that profession which had more to do with the world's wonderful advancement than any other, and advised them to adhere to that straight and undeviating line of conduct which should at all times characterize an engineer. By doing these things he felt that in future years they would reflect credit on their Alma Mater, which he regarded as one of the "greatest institutions in the Dominion."

The lengthy programme of speeches was relieved by musical selections, rendered in a most pleasing style by the Science Octette, the members of which this year are, Messrs. W. A. O'Flynn, W. A. Costain, P. S. McLean, G. B. Macaulay, J. H. Craig, W. C. Blackwood, R. B. Chandler, G. J. Mickler. The Octette is again under the leadership of Clayton E. Bush.

The success of the twenty-second annual dinner is due to the united efforts of the entire executive, and to the able assistance of Prof. Wright and others of the staff.

W. T. Main, '93, is division engineer, on the Wisconsin division of the C. & N. W. Ry.

W. G. McGeorge, '08, is conducting a general engineering practice in Chatham, Ont.

A. T. C. McMaster, '01, is engineer on design and construction of basic converter and reveberatory plants, The Canadian Copper Co., Copper Cliff, Ontario.

J. L. Morris, '81, and W. J. Moore, '06, are in partnership at Pembroke, Ont, under the name of Morris and Moore, surveyors and general engineers.

A. E. Pickering, '04, is with the Lake Superior Power Co., as superintendent.

R. S. Smart, '04, is in Ottawa, as manager Fetherstonhaugh & Co., Patent Solicitors.

P. H. Stock, '09, is resident engineer, for the Niagara, St. Catharines and Toronto Ry.

W. V. Taylor, '93, is Harbour Commissioner for the city of Quebec.

A. F. Wells, '04, is president of the firm of Wells and Gray, Ltd., engineers and contractors, Toronto.

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INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE
AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO.

Published monthly during the College year by the University of Toronto Engineering Society

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EDITORIAL

LIST OF GRADUATES WHOSE ADDRESSES ARE UNKNOWN.

The endeavor to have as complete a list as possible of the present addresses of graduates will be greatly aided by any information that may come from readers of Applied Science who are acquainted with the whereabouts of any of these men.

1882—D. Jeffrey, J. H. Kennedy.
1885—E. E. Henderson.
1887—A. E. Lott, F. Martin.
1888—D. B. Brown, K. Rose.
1892—J. R. Allan.
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1895—W. M. Brodie, H. S. Hull.
1897—W. R. Smiley, E. A. Weldon.

1898—J. E. Lavrock, F. W. McNaughton, A. E. Shipley.

1899—G. A. Clothier, C. Cooper, J. C. Elliott, W. E. Foreman, E. Guy.

1900—J. Clark, J. E. Davison, H. A. Dixon, H. S. Holcroft, J. C. Johnston, R. E. McArthur.

1901—J. L. R. Parsons.

1902—J. M. Brown, A. R. Campbell, F. T. Conlon, H. V. Connor, A. C. Goodwin, J. T. Mackay, R. S. Mennie.

1903—H. G. Acres, R. E. George, W. A. Gourlay, J. A. Horton, A. L. McNaughton, C. A. Maus, M. L. Miller.

1904—P. C. Coates, O. B. McCuaig, G. G. McEwen, E. E. Moore, H. M. Weir.

1905—D. W. McKenzie, E. D. O'Brien, E. P. A. Phillips, C. H. Shirriff, W. F. Stubbs.

1906—C. Johnston, N. R. Robertson.

1907—A. P. Augustine, G. H. Broughton, R. A. Hare, E. W. Kay, D. J. McGugan, F. W. McNeil, J. D. Murray, A. F. Wilson.

1908—R. H. Douglas, C. Flint, W. A. Robinson, J. J. Stock.

BOOK REVIEWS.

Principles of Metallurgy.—Fulton.

(*McGraw-Hall Book Company, New York—528 pages 6 ins x 9 ins. Illustrated.*)

In this age of advancement, it is particularly noticeable that the conditions which have brought about the present tendency toward specialization have, of necessity, forced a similar state of affairs on the scientific literature of the day. It is only at long intervals that some author has the clear-sighted perception which enables him to compile a work in such a manner as to be extremely valuable to the practical reader who wishes far-reaching fundamental principles rather than minute descriptions of some one department.

That Professor Fulton has foreseen a long-felt want is quite evident when the scope of the above book is examined.

The writer has paid a great deal of attention to the very important subject of metallic alloys. In the chapter on "Physical Mixtures and Thermal Analysis," cooling curves and freezing point curves are very clearly discussed. From this, the author goes on to point out the various types of Binary freezing point curves. The pages devoted to Ternary systems might well have been added to. This part of the subject of metallic alloys is one which, above all, causes the student the most trouble; and it is little to be wondered at when one takes into consideration the manner in which information on the subject is scattered throughout the scientific journals.

Further on, various alloys are discussed, among which are the copper-zinc, copper-aluminum, copper-tin series. The diagrams for these alloys are plainly shown in full-page size. These diagrams, when taken with the discussion of the commercially most important mixtures, furnish a large amount of valuable information. The iron-carbon series has been condensed in a manner slightly out of keeping with its importance, although the writer seems to have recognized this by referring the reader to "works on metallography of iron and steel." A few of these references might well have been quoted, for although some references are given, yet they can hardly be said to be suitable for the average reader.

In chapter VI., the measurement of high temperature is taken up in an interesting manner, which, to say the least, robs a large subject of the usual mass of detail both wearisome and so often needless.

The chapter on "Slag," as pointed out in the preface, is based largely on the work of J. H. L. Vogt. The amount of condensed material in this section of the book is enormous. The mineralogical nature of slag, cooling curves, formation temperatures, specific heat and latent heat of fusion of slag are subjects which are briefly but ably set forth. The tables given in connection with these headings are comprehensive and clear.

Passing on to the next chapter, there are thirty-six pages devoted to mattes, bullion and splise. The various sulphide systems are illustrated by means of freezing point curves. In pointing out the characteristics of these systems, a large number of practical details are given which add to the value of the discussion.

From chapter XIII. one gets a very good idea of the various types of furnaces used in metallurgical work. The writer touches on the electric furnace. It might have been advisable to give more examples of furnaces used in this extremely important and growing branch of the industry.

Besides the chapters specially mentioned are those on Physical Properties of Metals, Typical Metallurgical Operations, Refractory Materials for Furnaces, Fuels, Cumbustion, and a final section devoted to illustrating the physics and chemistry of a smelting operation.

One very good feature of the book is the large number of references given, some suitable for the average, and others for the advanced reader. The illustrations throughout are very clear. Taken as a whole, the book is a valuable addition to metallurgical literature.

(***Reviewed by T. R. Loudon, B.A.,Sc., Dept. of Metallurgy.***)

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Index to Advertisers

Acton Publishing Co., Ltd., The . . . xvi
Aikenhead Hardware Co., Ltd. . . . v
Art Metropole, Ltd., The iv

Bowman & Connor . . . Inside Back Cover
Babcock & Wilcox, Ltd. xv
Barber & Young . . . Inside Back Cover
Bertram, The John & Sons Co., Ltd. . . xi
Berger, C. L. & Sons v

Canadian Electrical News . Outside Back Cover
Canadian Engineer, The i
Canadian Kodak Co., Ltd. xviii
Canadian Westinghouse Co., Ltd. Outside Back Cover
Consolidated Optical Co., Ltd. x
Construction . . . . Outside Back Cover

Dietzgen Eugene Co., Ltd. xvi
Dominion Bridge Co., Ltd. vi
Dodge Manufacturing Co. xv
Don Valley Brick Works ii
Duckworth-Boyer, Engineering and Inspection Co., Ltd., The . . Inside Back Cover

Eaton, The T., Co., Ltd. vi
Engineering News Publishing Co. Inside Front Cover
Engineering Society xvii

Farmer Bros. xvii
Francis, W. J. . . . . Inside Back Cover

Goldie & McCullough Co., Ltd. . . . xiv
Gurley, W. and L. E. ix

Higgins Ink xvii

Inglis, The John Co., Ltd. viii

Leonard, E., & Sons xi
Lufkin Rule Co., Ltd. . . Inside Back Cover
Laurie & Lamb xiii

McGraw Publishing Co. xxi
McLean Publishing Co. i
Mitchell, Chas. H. & Percival H. Inside Back Cover

Rail Joint Co. of Canada, Ltd., The . . . v
Roman Stone Co., Ltd., The iii

Stock & Bickle vii

Trussed Concrete Steel Co., Ltd. . . . xix
Tugwell, H. C. & Co., Ltd. xvi

Vannevar & Co. xvii

University of Toronto xx

Waterous Engine Works xii
Weston Electrical Instrument Co. . . . x